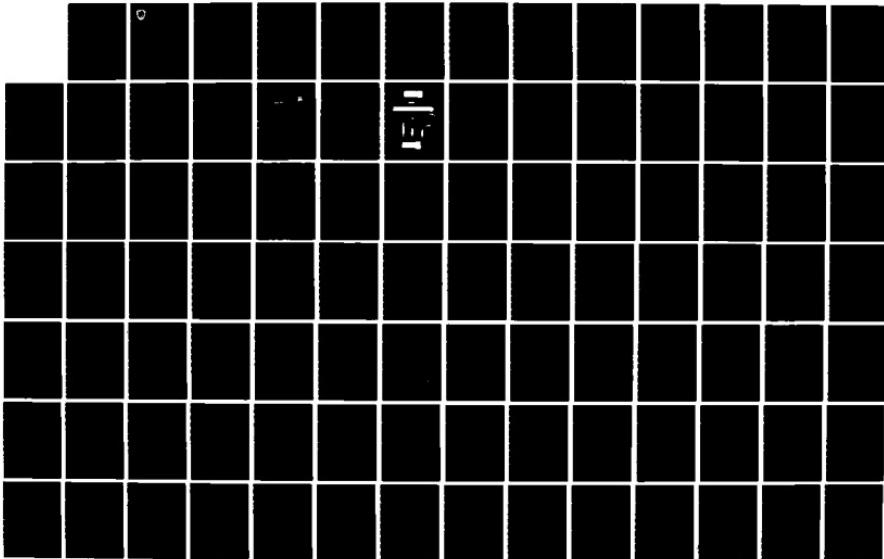
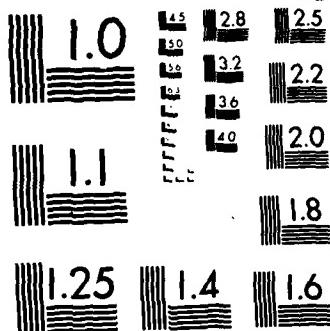


RD-A156 775    METHODOLOGY INVESTIGATION OF 120-MM DIFFERENTIAL WEAPON    1/4  
CHAMBER PRESSURE MEASUREMENT(U) ARMY COMBAT SYSTEMS  
TEST ACTIVITY (PROV) ABERDEEN PROVING GRO.

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METHODOLOGY INVESTIGATION

FINAL REPORT

OF

120-MM DIFFERENTIAL WEAPON CHAMBER

PRESSURE MEASUREMENT

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US ARMY COMBAT SYSTEMS TEST ACTIVITY  
ABERDEEN PROVING GROUND, MD 21005-5059

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <b>A methodology investigation was conducted to improve the quality of chamber pressure measurement in the 120-mm gun. Two 105-mm gun tubes were each drilled to accept two sets of pressure gages for a comparison of gage performance. An evaluation of the Kistler 6211, Yuma T-8, and Yuma ES15 gages demonstrated that static calibration of gages does not eliminate the possibility of poor gage performance. Anomalies in differential pressure records were observed to have a detrimental effect on differential peak pressures for some rounds, and a</b>		

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20. negligible effect on other rounds. A formal logbook of gage performance under firing conditions is recommended as a necessary step in improving pressure measurement. Also recommended is a shooting test of gages in gun tubes drilled similarly to those in this report, to compare gage performance under controlled firing conditions. In addition to a shooting test of gages, specific actions are recommended to determine the cause of the difference between the performance of gages during static calibration and the performance in a gun tube.

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## FOREWORD

The US Army Combat Systems Test Activity, Aberdeen Proving Ground, MD, initiated this study as the result of a Committee established to improve the measurement of chamber pressure in the 120-mm gun.

Acknowledgement is given to Mr. Mike Manco for coordinating ammunition and weapon requirements, and serving as test director. Mr. Mike Yuran is recognized for rapidly processing the raw data, Mr. Roy Gross for producing the engineering drawings necessary to begin preparing the tubes, and Mr. Max Foster for assisting in the laboratory check of the gages. The technicians of Field Instrumentation Branch are commended for their conscientious effort in producing the best possible test data.

Ms. Lloyd Foss was responsible for coding the linearization and polynomial coefficient entry programs.

The authors would also like to express their sincere appreciation to Mr. Welton Phillips of Yuma Proving Ground, who designed several transducers that were used, and provided valuable guidance during the firing phase of this project.

## SECTION 1. SUMMARY

### 1.1 BACKGROUND

During DT II testing of the 120-mm XM865 cartridge, initial negative differential pressures exceeding 5000 psi were encountered. Since a -5000 psi differential pressure is the level at which concerns begin to develop for weapon safety, the differential pressure data were carefully examined. Inspection of the data revealed an anomaly in the pressure traces which may have contributed to exceeding the -5000 psi criteria. Forward and rear chamber pressure traces are normally expected to return to zero baseline at a uniform rate following peak pressure, and are expected to produce a differential plot which returns to zero baseline shortly after maximum differential pressure. During DT II of the XM865 cartridge, rear and forward traces did not return to zero baseline at a uniform rate. In many instances, the forward gage pressure crossed over and exceeded the rear gage pressure after peak pressure. Examination of pressure data from other weapons, data acquisition systems, and pressure gages proved that the problem is not uncommon. Complete discussion of pressure wave analysis is described by Horst, et.al. in References 3 through 5.

Figure 1.1-1 is an example of a good measurement of differential pressure.

In the 120-mm tank gun, the differential pressure should approach zero when the chamber pressure is decaying from 90% to 50% of maximum value. Note that in Figure 1.1-1, for example, the differential pressure is zero at 8.5 milliseconds. The chamber pressure has decayed to 68% of peak value this time. Figure 1.1-2 illustrates an erroneous differential pressure measurement. Note that at peak pressure, the forward pressure is greater than the rear pressure.

Such a condition could only happen in the presence of large pressure waves, yet no such waves are present. Also note that at the end of the plot, after the projectile has left the tube, the forward pressure is approximately 1500 psi larger than the rear pressure.

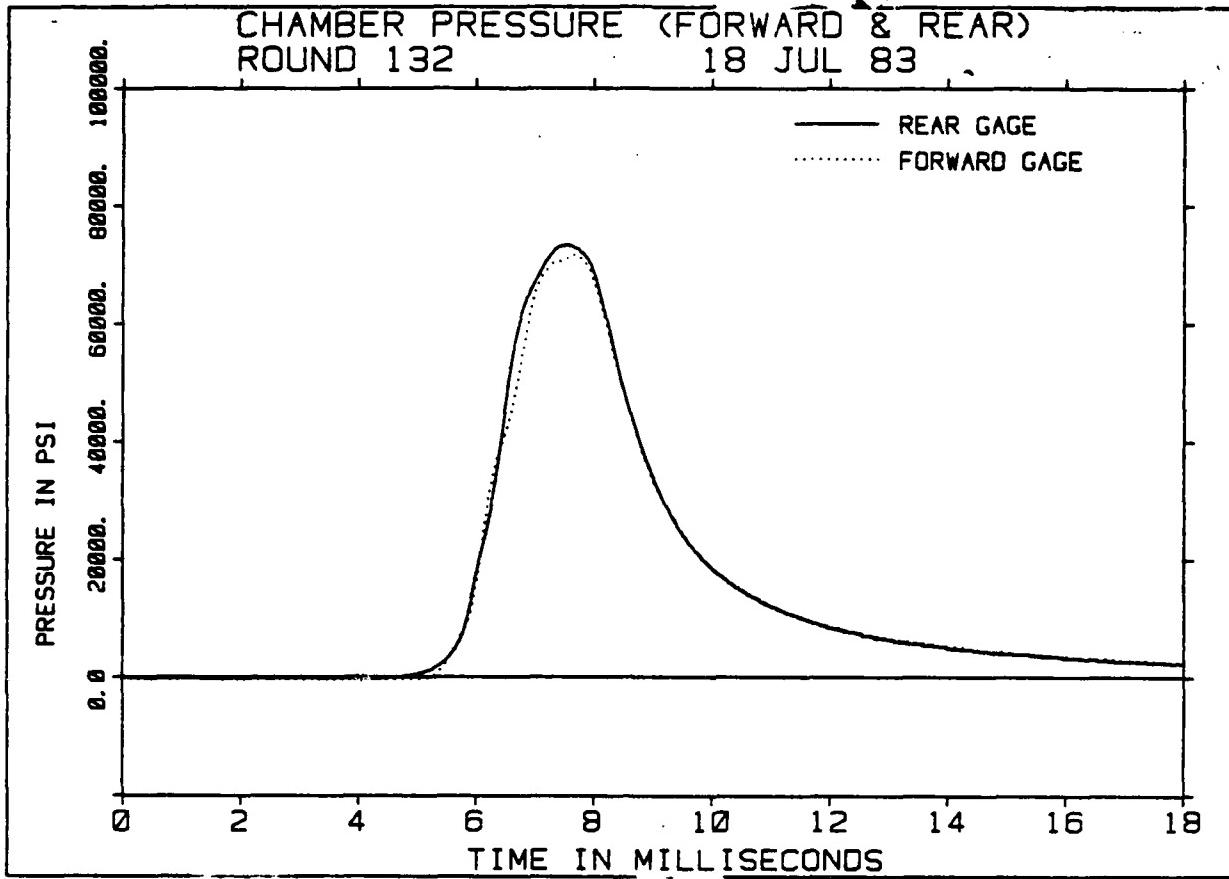
Such a result is physically impossible. It indicates a large pressure gradient exists from front to rear, which would imply that gas was flowing at a very high velocity from the muzzle through the breech!

It is interesting to note that both the good and bad measurements shown in the last two plots were obtained from the same two Kistler 6211 transducers (No. 151647 and 151652) on the same day.

Figures 1.1-3 and 1.1-4 of the 105-mm M774 cartridge do not exhibit the crossover effect, but the forward and rear gage traces do not approach the zero baseline in the expected manner. The resulting differential plot does not reach the zero axis after 36 milliseconds, suggesting gage malfunction. These problems have been noticed before, but have been largely dismissed as an acceptable feature of a differential pressure record since the peak differential occurs well before the crossover or zero baseline offset. However, maximum performance is demanded of weapon systems such as the 120-mm gun. What was once thought to be an insignificant factor may no longer be allowed to pass without careful scrutiny. Therefore, this methodology investigation was initiated to offer some explanation for apparent anomalies in chamber pressure records.

CHAMBER PRESSURE (FORWARD & REAR)  
ROUND 132

18 JUL 83

DIFFERENTIAL PRESSURE (REAR-FORWARD)  
ROUND 132

18 JUL 83

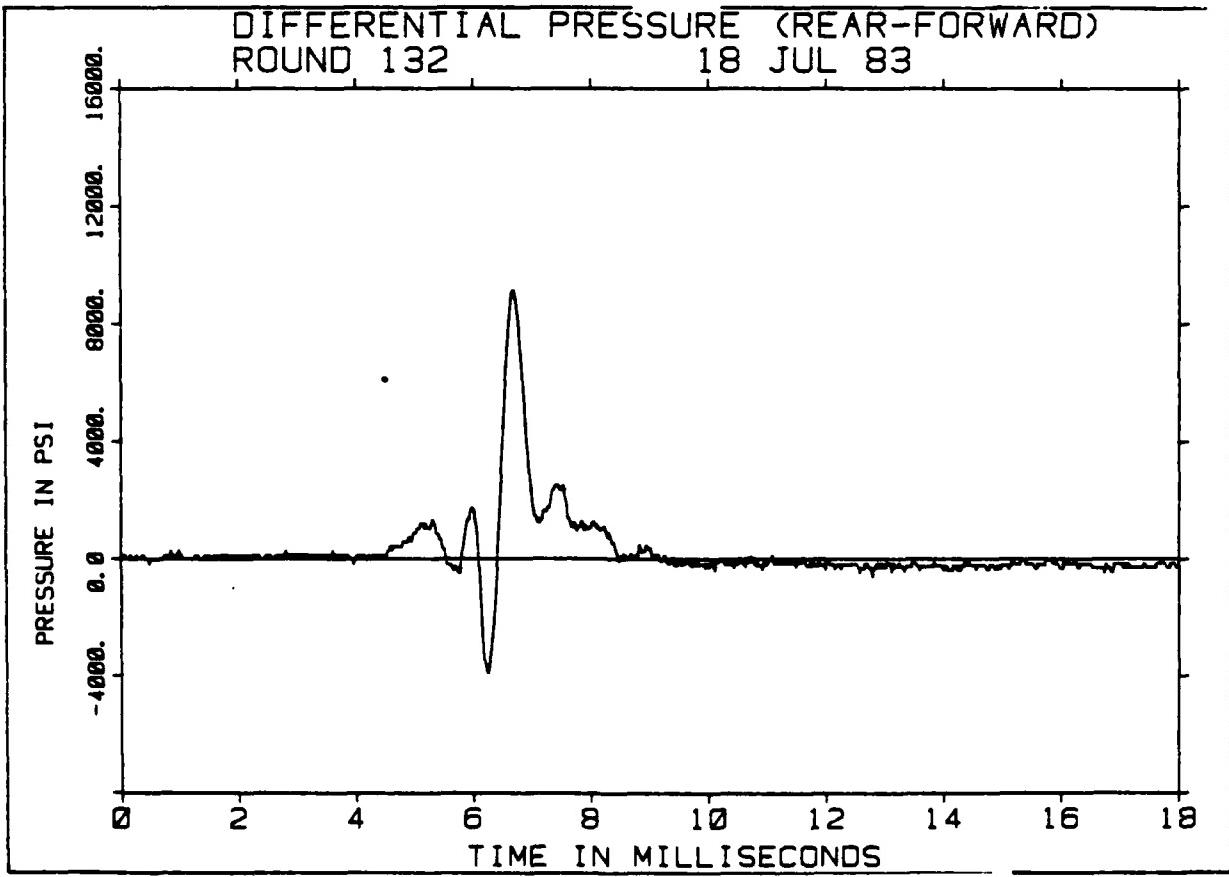
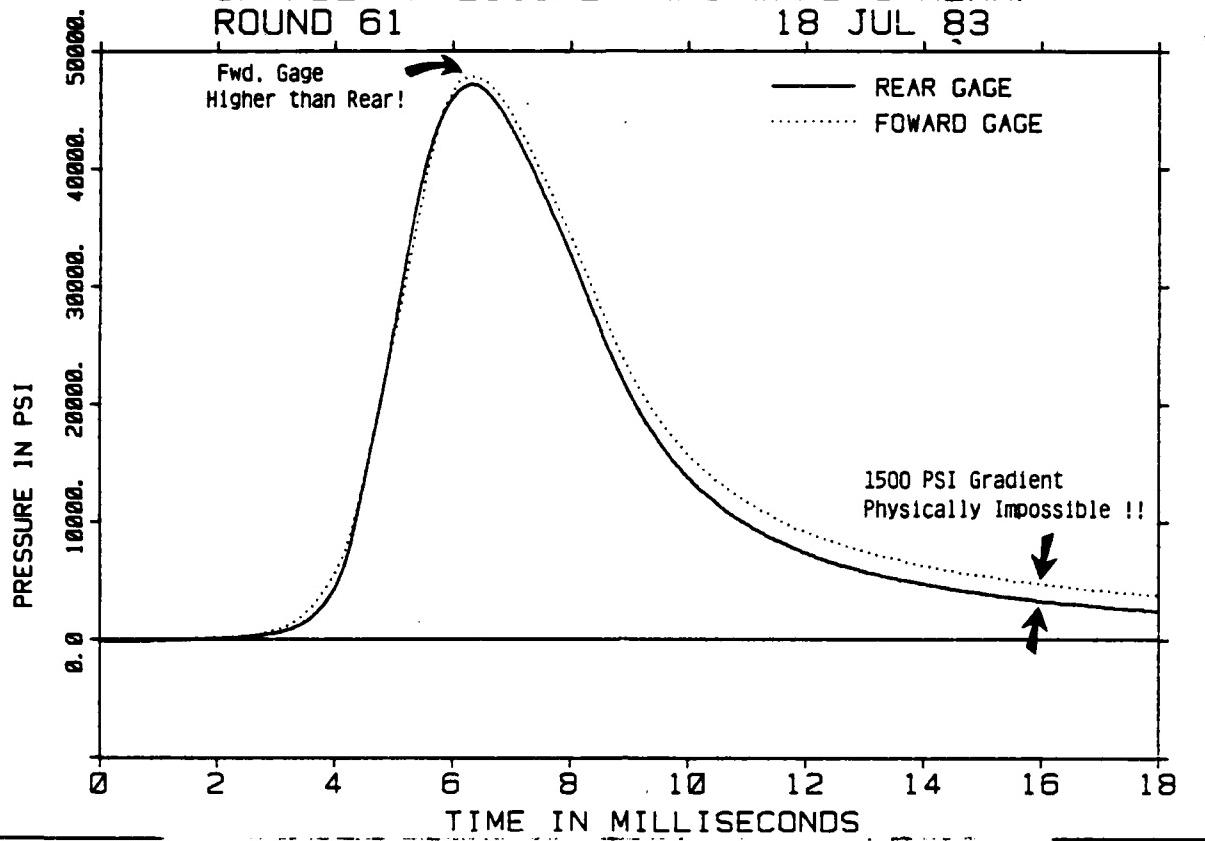


Figure 1.1-1. Example of a good differential pressure measurement.

1.1 (Cont'd)

CHAMBER PRESSURE (FORWARD & REAR)  
ROUND 61

18 JUL 83

DIFFERENTIAL PRESSURE (REAR-FORWARD)  
ROUND 61

18 JUL 83

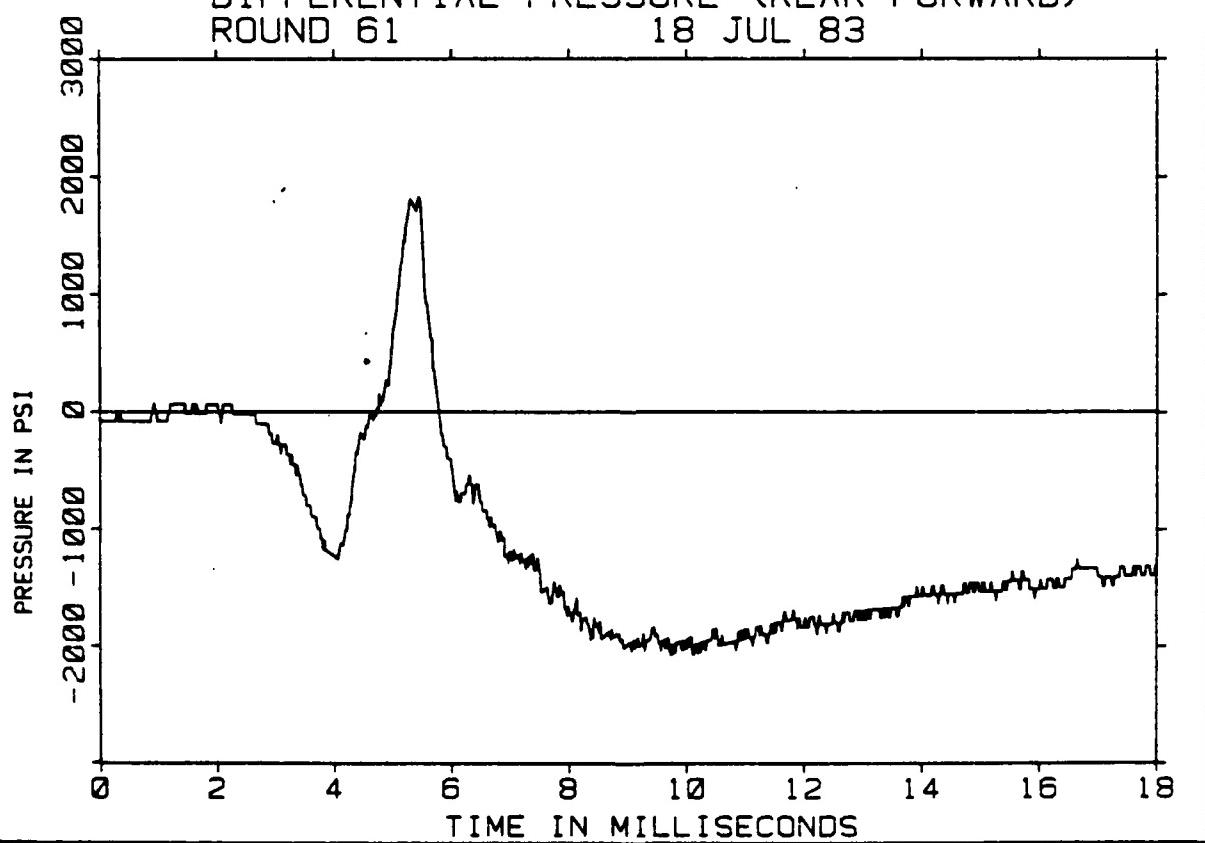


Figure 1.1-2. Example of a poor differential pressure measurement.

PISTOL UNLOADING OR P/I, TEST NUMBER  
ROLND NO. 28 DATE FIRED: 6 MAR. 84  
HMMO TEMP: +20 DEG F

1.1 (Cont'd)

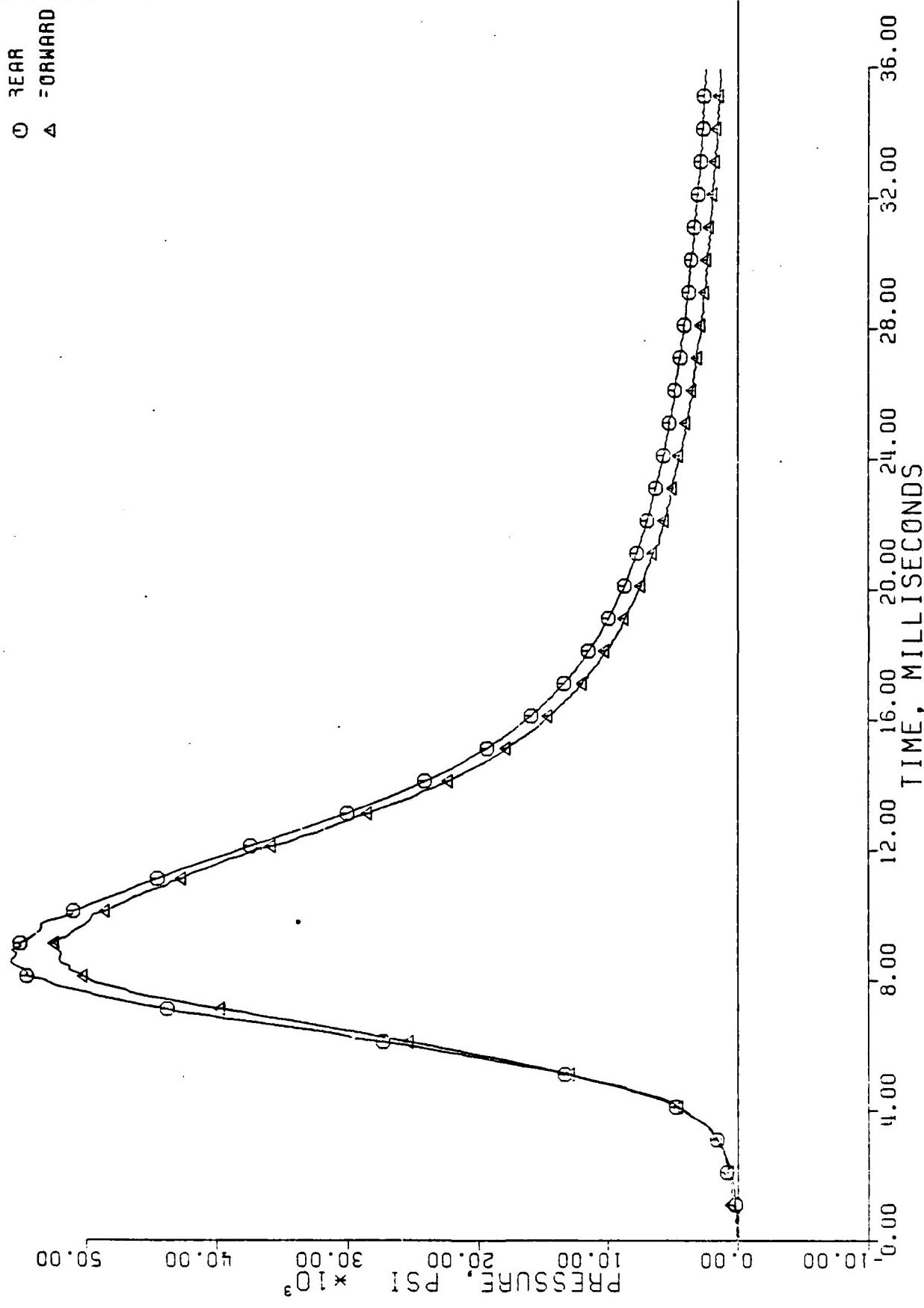


Figure 1.1-3. Chamber Pressure.

MASTER CALIBRATION OF M774, 105-MM APF'S      CTG/TEMP COEFFICIENT PHASE  
ROUND NO. 28      DATE FIRED: 6 MAR. 84      AMMO TEMP: +20 DEG F

1.1 (Cont'd)

① REAR FORWARD

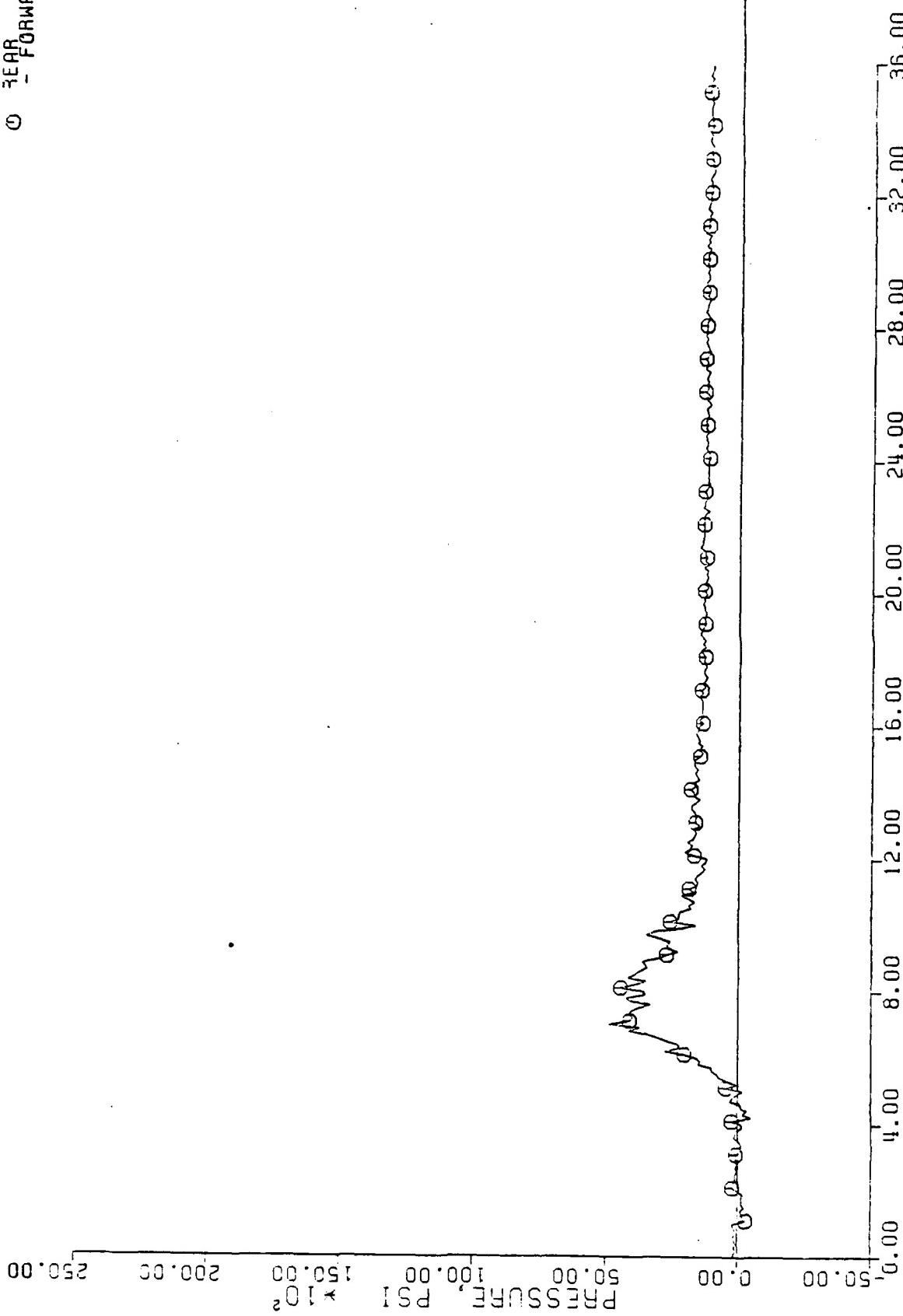


Figure 1.1-4. Chamber pressure.

## 1.2 OBJECTIVES

The purpose of this investigation is to improve the measurement of differential weapon chamber pressure. The improvement is to be accomplished either through the use of different transducers and measurement procedures, or through a better understanding of the results produced by existing transducers and measurement procedures. The following items are the object of the investigation:

- a. Compare the performance of three alternative transducers (T-8M, E15MA, and ES15M) to the performance of the currently used Kistler 6211 transducer.
- b. Compare the performance of several combinations of the currently used pressure transducer.
- c. Compare the performance of two different models of charge amplifiers.
- d. Compare the effect of linearizing pressure data based on the calibration records for the pressure gages.

The specific comparisons to be made are a quantitative analysis of pressure amplitude and a qualitative analysis of the shape of pressure traces. Of primary importance is the identification of improperly shaped differential waveforms and the resulting effect on differential pressure amplitudes.

## 1.3 SUMMARY OF PROCEDURES

For this investigation, two 105-mm tank guns were used because of the large expense and limited availability of 120-mm tubes and ammunition. The 105-mm is thought to be an acceptable second choice, since the problems to be studied are not unique to the 120-mm gun.

The gun tubes were drilled for a pair of gages on the left and right side, 14.28 and 20.50 inches from the rear face of the tube as shown in Figure 1.3-1. A fifth gage was also mounted in the base of the cartridge case for the majority of the rounds fired. The first tube was drilled to accept 1-1/8 by 12 threaded adapters in the right side to permit testing several different types of pressure gages in the same tube. The second tube was drilled to accept a specific gage thread size, and all testing with that tube was conducted with two types of pressure gages.

Ammunition used throughout the test was the 105-mm M392A2 cartridge. Technical Manual information is shown in Figure 1.3-2.

Four different types of pressure gages were compared: Kistler 6211, Yuma ES15M, E15MA, and T-8M (fig. 1.3-3). The Yuma ES15 gage was used in the base of those cartridges which were drilled to accept a pressure gage. Kistler 6211 gages were used in the forward and rear positions on the left side of both tubes. The Yuma T-8, Yuma ES15 with adapters, and Kistler 6211 with adapters were used in the right side of the first tube. The Yuma ES15 was used in the right side of the second tube. Figure 1.3-4 illustrates gage placement.

## 2.1 (Cont'd)

Gages were reversed on the left side after round three, and on the right side after round six. When the left side was changed, differential pressure increased by approximately 1800 psi. When the right side was changed, differential pressure decreased by approximately 800 psi. Channel 3, Kistler 151647, produces consistently low peak pressures in both forward and rear positions.

Throughout this first phase of firing, there are no serious crossover effects or failures to return to zero. As shown on the plots for rounds 10 and 11, the left set of Kistler gages did develop a small negative offset toward the later part of the 13 round group. However, overall performance is considered acceptable with the exception of the low readings produced by gage 151647.

## SECTION 2. DETAILS OF INVESTIGATION

### 2.1 PHASE Ia, ROUNDS 1 THROUGH 13, TUBE 25970

Kistler 6211's were used in both the left and right sides of the tube. Gages SN 168650 and 168659 were mounted in adapters No. 11 and 12 in the right side of the tube. Both of these gages were new, with no previous record of firing performance. Gages SN 151647 and 151652 were mounted without adapters in the left side of the tube. These gages were selected based on performance during previous firing programs, where they demonstrated zero offset or crossover problems.

The Kistler 6211 differential pressure plots for rounds 1 to 13 exhibit little or no negative differential pressure, with positive peaks of approximately 3000 to 5000 psi. When the forward Kistler gages are subtracted from the base ES15 gage, the positive peak of the differential pressures are approximately 6500 to 9000 psi. A representative plot is shown for round T1.

These are not surprising results, since the rear gage is 14.28 inches forward of the base gage. The position of the forward and rear gages is largely determined by the physical constraints of the tube and tube mount. While it is recognized that the longest possible baseline between gages may produce the best indication of differential pressure, the preferred locations may not be accessible. In this case, an increase in differential pressure by a factor of two is evident when comparing the rear and base gage positions.

The effect of gage position on differential pressure is important when the -5000 psi criteria is considered. The -5000 psi criteria originated during tests of the zone 8 charge for the 155-mm, M198 artillery piece. Pressure gage spacing in the M198 is 35.6 inches. If the -5000 psi criteria are applied to the 105-mm M68 gun and the 120-mm tank gun, it is not clear that the criteria are valid. These guns have different gage spacing, different projectiles, different propelling charges, and different tubes. Therefore, a sensitivity plot of breech pressure versus negative differential pressure may be significantly different than the M198.

A comparison of positive peak differential pressures reveals no significant problems. Positive differential pressures between the forward and rear gages on both sides range from 2900 to 5700 psi. Variations between differential pressures on the left and right sides are from 500 to 2500 psi. This variation has been considered acceptable for differential pressure measurements, as noted by W. Scott Walton in Final Report, Improved Standardized Weapon Chamber Pressure Measurement. "In most measurements of differential pressure during which no waves are present, the forward transducer should read typically 2 to 5% lower than the rear transducer. If both transducers have an accuracy of  $\pm 2\%$ , the accuracy of this small differential pressure can be  $\pm 100\%$ !"

Charge amplifiers were changed during rounds 10 through 13. During laboratory testing and calibration prior to the firing phase, a difference was noted in time constants of the Kistler 504 charge amplifier and the Precision Filters 316 charge amplifier. Changing charge amplifiers produced no discernible change in peak differential pressure, but may be responsible for slight negative offsets on rounds 10 and 11.

7 (Cont'd)

(2) Test gage pairs under dynamic laboratory conditions. The Princeton Combustion Research Laboratory facility in USACSTA will be used for this phase of evaluation.

(3) Evaluate gage selection under controlled firing conditions. It is recommended that the tubes used in this report be used to match gages prior to use on ammunition acceptance tests. Although this is an expensive proposition, it should be possible to process a large number of gages once the tube and ammunition are available. Two pairs of gages can be evaluated simultaneously with these tubes, and only two or three rounds will be required to provide an indication of performance. While this will not eliminate all bad gage pairs, the cost savings and resulting improvement in data would be well worth the initial expense.

b. A log must be kept, describing all gage pair performance, detailing number of rounds fired, tube number, gage positions, and pressure levels measured. It is recommended that representative data plots of gage pair performance be maintained in the log. Only by this method will a historical record of performance be available to improve future pressure measurements.

c. To determine the cause of the difference between the performance of gages during static calibration and the performance in a gun tube, the following actions are recommended:

(1) Evaluate gage hysteresis characteristics.

(2) Evaluate the effect of heat on the gage.

(3) Return a bad gage to the manufacturer for evaluation. A Kistler 6211 gage used in this study, serial number 151647, produced consistently low peak pressure measurements. Analysis of this gage may provide some insight for an explanation of poor gage performance.

d. An effort should be made to increase the time constant of the Precision Filters 316 charge amplifiers.

particular pair of gages selected are very significant. However, if static calibration is not an indicator of gage performance, then internal function of the gage must be significantly different under dynamic conditions.

Each of the different models of gages used in this report are different in physical construction. Each exhibited some type of problem on the differential records. One pair of ES15 gages demonstrated a variety of anomalies over the course of six consecutive rounds. This performance is seldom, if ever, observed in the Kistler gage. Since gage positions were not changed during these six rounds and peak differential pressures were acceptable, it seems that the piezoelectric crystal performed more predictably in compression than during the decline in chamber pressure. Tube stresses during firing play an important role in this theory; a dynamic comparison of two gages can be performed in the laboratory, but offset and crossover have not been reproduced.

Whatever the cause of questionable differential records, it is clear that pressure records cannot be acquired with confidence unless there is some performance record supporting use of the particular pair of gages selected.

Offset and crossover on differential records are sometimes an indicator of gage problems which artificially change the amplitude of differential peak pressures. In the interest of consistently producing the best data possible, differential records with these features should be considered suspect, and the gages changed accordingly.

#### 1.6 CONCLUSIONS

a. Gages should first be statically calibrated, then evaluated according to performance under firing conditions. Due to the expense of culling gages by firing, this must be considered an interim solution. A laboratory test which adequately describes gage performance must be devised.

b. When offset and crossover effects on differential pressure records are observed they should be considered detrimental and a new pair of gages selected.

c. Gage adapters will not make a bad pair of gages into a good pair of gages, but should be used whenever possible to reduce stresses on the gage body and improve the precision of machining.

d. Changing charge amplifiers during field firing does not cause a large change in gage performance.

e. The distance between forward and rear gages has an effect on peak differential pressure amplitude and should be considered whenever discussing -5000 psi criteria during ammunition evaluation.

#### 1.7 RECOMMENDATIONS

a. Until gage performance is adequately understood for the purpose of differential pressure measurement, gage selection should be a three step process:

(1) Statically calibrate gages, then match gages for differential measurements based on scale factor and linearity.

The average base-forward gage maximum positive differential pressure for all rounds fired was 6800 psi, compared to the rear-forward peak of 3800 psi. This is a result of the large difference in gage spacing between the base and rear gages.

The performance of those gages which performed poorly could not be predicted through study of the static calibration records.

A pair of gages which demonstrated a significant positive offset on the plot of differential pressure were not greased for two consecutive rounds. The offset was not observed to be different due to the change in application of grease.

Gage position had a pronounced effect on differential records. Changing gage positions from forward to rear, and changing tubes can often be easily identified in tables of peak pressure and peak differential pressure.

For all but the worst sets of gages, maximum positive differential pressures ranged consistently from approximately 3000 to 5000 psi. The general shape of differential records from the left and right sets of gages were very similar when not distorted by offset or crossover despite differences in peak differential values.

Laboratory testing showed a dramatic difference between the time constants of the two types of charge amplifiers. The Kistler 504 and the Precision Filter 316 amplifiers were interchanged on 16 occasions to determine the magnitude of the difference under firing conditions. Six of the 16 cases produced a difference considered to be attributable to the relatively short time constant of the 316 amplifier, suggesting that the difference was masked by other variables in the remaining ten cases.

The Kistler gages used in this study did not vary significantly in performance when mounted in adapters or mounted directly in the gun tube. The gages with a history of questionable performance did not improve and the gages which performed properly continued to perform well throughout the test. It should be noted that the authors' experience with Kistler gages outside of this methodology test demonstrates that a good gage may not perform well in all tubes.

Section 2 of this report includes a description of gage performance, followed by a table of peak pressures, comparative plots of gage performance by round number and plots of peak and differential pressure versus time. Rounds are numbered consecutively from T1 through T88, with the exception of several rounds which were refired. If refired, the round was numbered out of sequence to permit identification on data tapes. An example is round No. 14, which is labeled T214 to denote two refirings.

## 1.5 ANALYSIS

Given a pair of gages with acceptable static calibration records, it has been demonstrated that acceptable differential firing records are not assured. Anomalies in gage performance have been attributed to heat on the gage during powder combustion, strain on the gage induced by chamber pressure, and inherent nonlinearities in the gage. Although none of these factors has been completely eliminated by the evidence provided in this report, the gage mounting and the

### 1.3 (Cont'd)

Several different plots were generated for each round fired. For those rounds drilled to accept a gage in the base of the cartridge case, eight plots were made and are labeled with the following scheme:

a. Pressure versus time, right side, rear and forward gages labeled "Measurement No. 1."

b. Pressure versus time, left side, rear and forward gages labeled "Measurement No. 2."

c. Differential pressure versus time, right side, rear minus forward gage labeled "Measurement No. 1."

d. Differential pressure versus time, left side, rear minus forward gage labeled "Measurement No. 2."

e. Pressure versus time, right side, base and forward gages labeled "Measurement No. 3."

f. Pressure versus time, left side, base and forward gages labeled "Measurement No. 4."

g. Differential pressure versus time, right side, base minus forward gage labeled "Measurement No. 3."

h. Differential pressure versus time, left side, base minus forward gage labeled "Measurement No. 4."

Emphasis was placed on evaluation of the Kistler 6211, since it is the standard gage for all 120-mm testing. Several Kistler gages were used which had produced questionable results during previous firing programs.

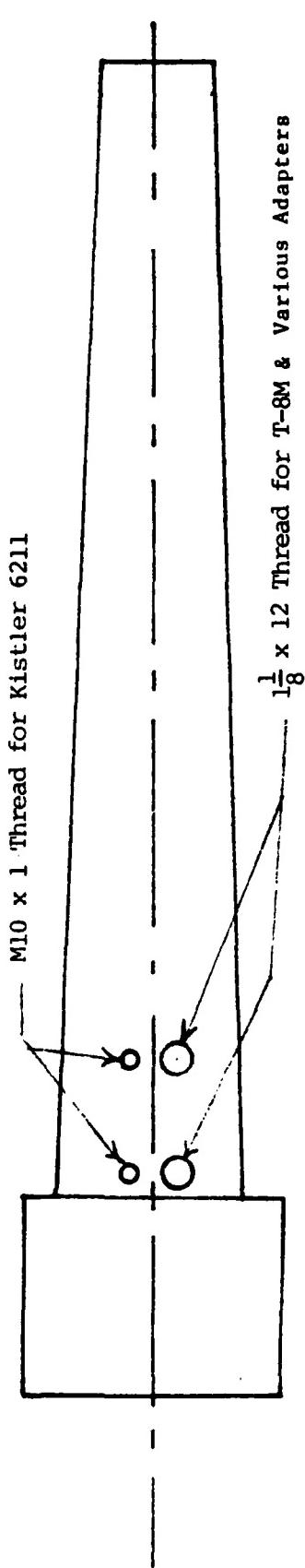
During the laboratory preparation for the firing phase of the investigation, a difference in time constants was noted between the Precision Filters 316 charge amplifier and the Kistler 504 charge amplifier. The amplifiers were interchanged during the test to detect any changes in data due to differences in time constants.

### 1.4 SUMMARY OF RESULTS

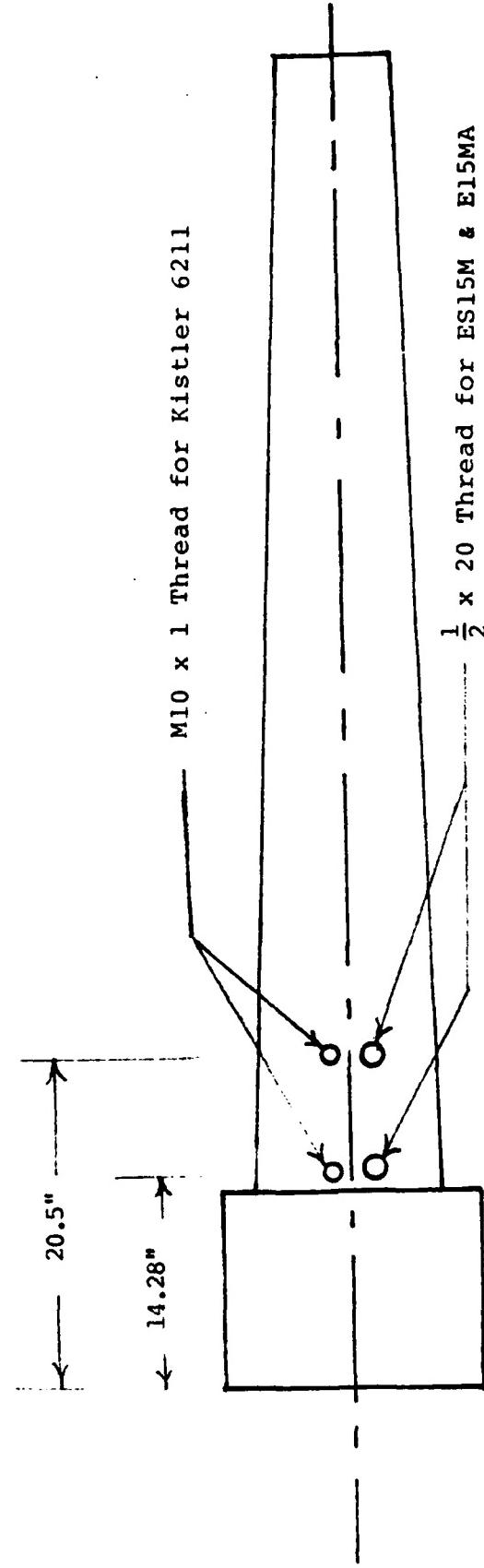
Each of the four gage models used exhibited some type of irregularity during the test. Gages ES15 and T-8 demonstrated a high frequency oscillation on the differential plots, which was not present in the performance of the Kistler 6211 gages.

Offset and crossover on differential records did not have a definitive effect on the differential peak amplitudes. Certain sets of differential records with offset or crossover are within the expected range of peak differential pressure, while other records are clearly wrong.

1.3 (Cont'd)



TUBE #25970



TUBE #25151

Figure 1.3-4. Schematic diagram of gage placement in M68 gun tube.

1.3 (Cont'd)

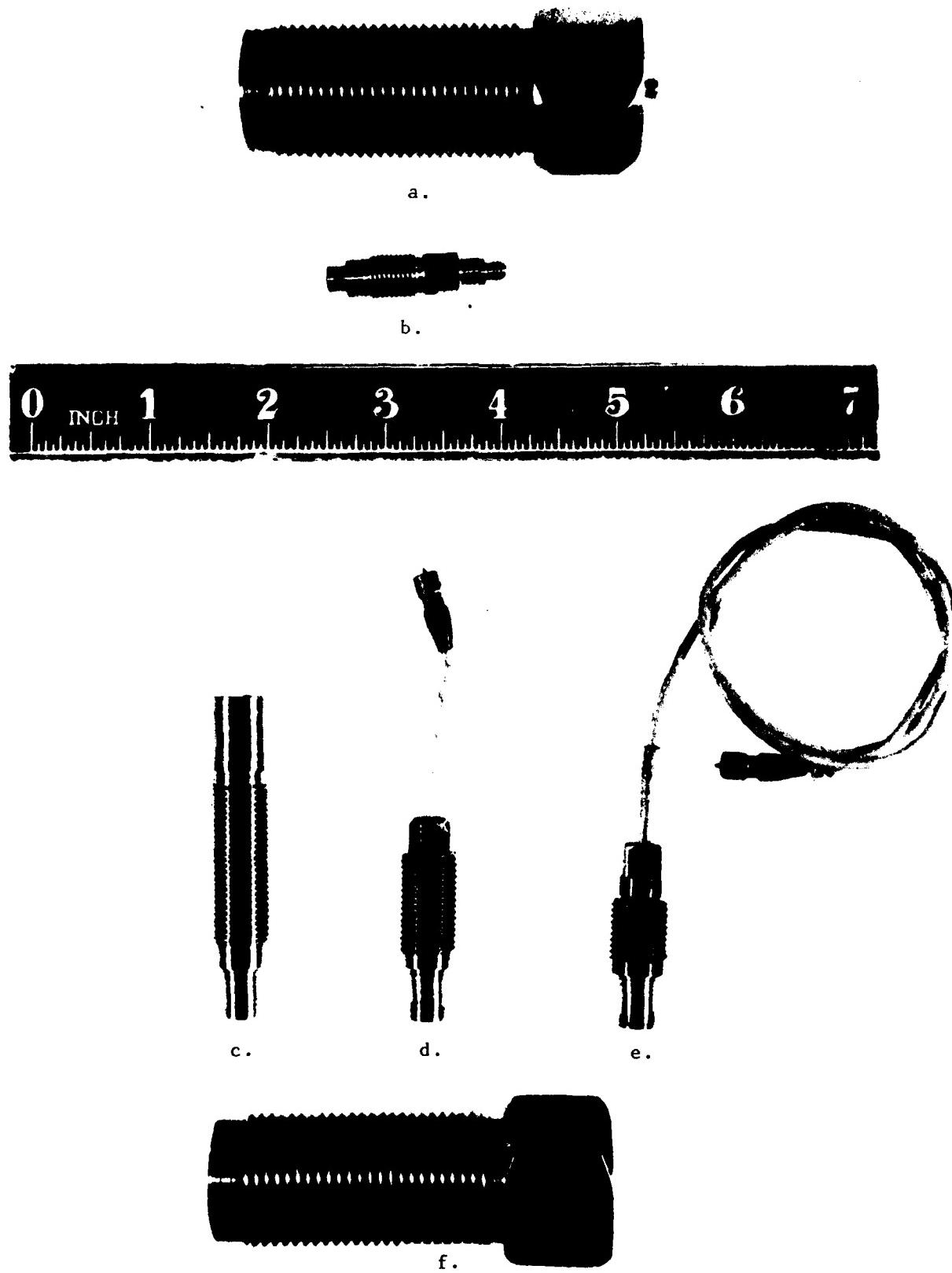


Figure 1.3-3. a. Yuma T-8M; b. Kistler 6211; c. Yuma E15M; d. Yuma E15MA; e. Yuma ES15M; f. Adapter for ES15 gage.

### 1.3 (Cont'd)

sheathed core is spin stabilized and penetrates target solely by kinetic energy.

#### Difference Between Models:

The M392 cartridge is of United Kingdom manufacture and bears the U. K. designation of L36A1. The M392 is fitted with U. K. Primer L4A1 or L4A2.

#### Tabulated Data:

##### Complete round:

Type ----- APDS-T  
Weight ----- 41.0 lbs.  
Length ----- 33.0 in.  
Cannon used with ----- M68

##### Projectile:

Body material ----- Tungsten carbide core  
Color ----- Black w/white marking

##### Components:

Cartridge case ----- M115, M115B1  
Propelling charge ----- M30 (T36)  
Primer ----- M80A1  
Tracer ----- M13

##### Performance:

Maximum range ----- 36,745 meters  
(40,162 yds.)  
Muzzle velocity ----- 1,478 mps  
(4,850 fps)

#### Temperature Limits:

##### Firing:

Lower limit ----- - 40°F  
Upper limit ----- + 125°F

##### Storage:

Lower limit ----- - 80°F (for period not more than 3 days)  
Upper limit ----- + 160°F (for period not more than 4 hrs/day)

\* Packing ----- 1 round per fiber container; 2 containers per wooden box

##### \* Packing Box:

Weight ----- 126 lbs.  
Dimensions ----- 39-7/8 x 14-1/8 x 8-23/32 in.  
Cube ----- 2.8 cu. ft.

\* NOTE: See SC for complete packing data including NSN's.

#### Shipping and Storage Data:

Quantity-distance class ----- 4  
Storage compatibility ----- E  
DOT shipping class ----- B  
DOT designation ----- AMMUNITION FOR CANNON WITH SOLID PROJECTILES  
DODAC ----- 1315-C505, C506  
Drawing number ----- 8863427

#### Limitations:

United Kingdom Cartridge L28A1, similar to the M392 except for its primer (L1A2, L1A3 or L1A4) is not to be fired in 105-mm Gun M68, except under combat emergency conditions. The clip will remain on the cartridge case at all times until the cartridge is partially chambered.

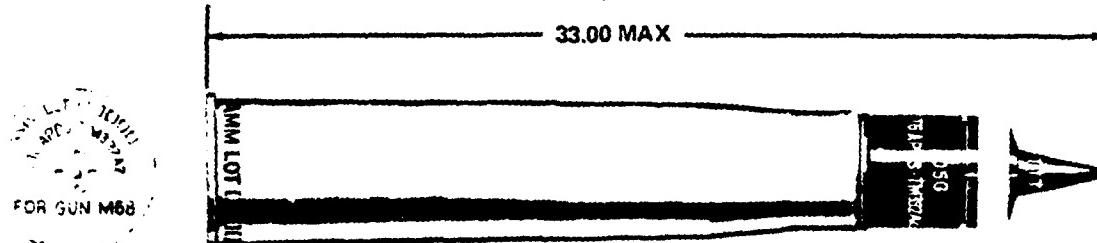
#### References:

SC 1305/30-IL  
SB 700-20  
AMCP 700-3-3  
TM 9-1000-213-35  
TM 9-1300-251-20  
TM 9-2350-215-10

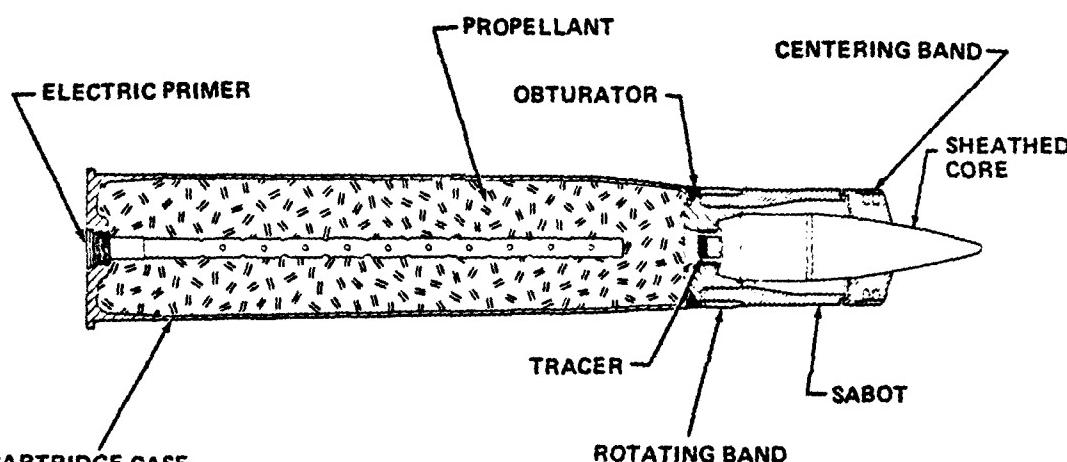
Figure 1.3-2 (Cont'd)

1.3 (Cont'd)

CARTRIDGE, 105-MILLIMETER: APDS-T, M392A2 AND M392



AR199819



AR199818

Type Classification:

M392A2 -----	Std OTCM 38116
M392 -----	Std OTCM 38116 dtd 1961

Use:

This cartridge is a hypervelocity armor-piercing type with discarding sabot, intended for use in 105-mm guns against armored targets.

Description:

The projectile consists of a sheathed tungsten carbide core with tracer and a sabot. The core, which is the armor-piercing element, is

carried within the sheath with the sabot assembled on the exterior surface. A plastic band is positioned on the outside diameter of the sabot at the forward end. A fiber rotating band and a rubber obturator are assembled on the outside diameter near the base of the sabot. The igniter tube of the electric primer extends almost the entire length of the propellant loosely packed in the cartridge case.

Functioning:

The electrically initiated primer ignites the propelling charge. Gases produced by the burning propellant propel the projectile from the gun and ignite the tracer which burns for a minimum of 2.5 seconds. Setback, centrifugal and air pressure forces cause the sabot to discard upon leaving the gun tube. The

Figure 1.3-2. 105-mm M392A2 cartridge.

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This image shows a document page that has been severely redacted. The original text is visible as extremely faint, illegible markings. Some larger, darker shapes suggest where specific words or lines were once present but have since been obscured. There are also some faint horizontal lines and what might be signatures or official seals.

This figure is a hand-drawn map of a river network. The main river flows from the bottom right towards the top left. Several tributaries enter the main river from the right side. Point A is located on one of these tributaries. Points B through Z are marked along the main river and its tributaries. A legend in the bottom right corner provides the following information:

- 1/2 mile
- 1/4 mile
- 1/8 mile
- 1/16 mile
- 1/32 mile
- 1/64 mile
- 1/128 mile
- 1/256 mile

The map also includes several labels such as "RIVER", "Tributary", "Main River", and "Point A".

TOURIST INFORMATION	
NAME	JOHN D. HARRIS
ADDRESS	1234 FAIRFIELD DR.
CITY	SPRINGFIELD
STATE	ILLINOIS
ZIP CODE	62704
PHONE NUMBER	(217) 555-1234

218-2007

Page 10

TABLE 2.1-1. CHAMBER PRESSURE DATA - PHASE 1a

105-mm Tank Gun  
 Tube SN 25570  
 Cartridge: M392A2  
 Temperature: +70° F  
 Date Fired: 22 August 1984

Rd No.	Ch 1	Amp Position	Ch 2	Amp Position	Ch 3	Amp Position	Ch 4	Amp Position	Ch 5	Amp Position	Maximum Chamber Pressure, Kpsi		Maximum Initial + P <sub>0</sub> , psi						
											Kistler No. 168650 in Adapter No. 11	Kistler No. 168659 in Adapter No. 12	Kistler No. 151647	Kistler No. 151652					
T1	57.3	316	Rear	54.4	316	Forward	55.1	316	Rear	54.1	316	Forward	59.1	316	Base	3990	3100	7400	7900
T2	57.4	316	Rear	54.6	316	Forward	55.2	316	Rear	54.4	316	Forward	59.1	316	Base	4300	2980	7500	8000
T3	58.0	316	Rear	55.6	316	Forward	56.0	316	Rear	55.1	316	Forward	NR	316	-	4160	2930	NA	NA
T4	55.7	316	Rear	54.0	316	Forward	52.3	316	Forward	55.4	316	Rear	57.7	316	Base	3870	4350	7400	8400
T5	56.1	316	Rear	54.6	316	Forward	52.9	316	Forward	56.0	316	Rear	58.1	316	Base	3760	4600	7100	8900
T6	57.3	316	Rear	55.0	316	Forward	53.8	316	Forward	58.0	316	Rear	NR	316	-	4260	4970	NA	NA
T7	55.0	316	Forward	56.3	316	Rear	53.1	316	Forward	57.3	316	Rear	58.7	316	Base	2980	4980	6600	8100
T8	54.6	316	Forward	55.7	316	Rear	52.5	316	Forward	56.6	316	Rear	58.1	316	Base	3190	5330	7000	8900
T9	55.7	316	Forward	56.9	316	Rear	54.0	316	Forward	57.9	316	Rear	NR	316	-	3510	4990	NA	NA
T10	55.2	504	Forward	56.3	316	Rear	54.4	504	Forward	56.9	316	Rear	58.4	316	Base	3130	4600	6700	8000
T11	53.6	504	Forward	54.6	316	Rear	52.7	504	Forward	55.1	316	Rear	56.6	316	Base	3490	3980	6400	7200
T12	54.7	316	Forward	55.6	504	Rear	52.6	316	Forward	57.2	504	Rear	57.7	316	Base	3130	5680	6500	7800
T13	54.4	316	Forward	55.8	504	Rear	53.0	316	Forward	57.5	504	Rear	58.0	316	Base	3630	5650	7100	8100

NA = Not applicable.

NR = Not recorded.

Ch = Channel.

2.1 (Cont'd)

MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER

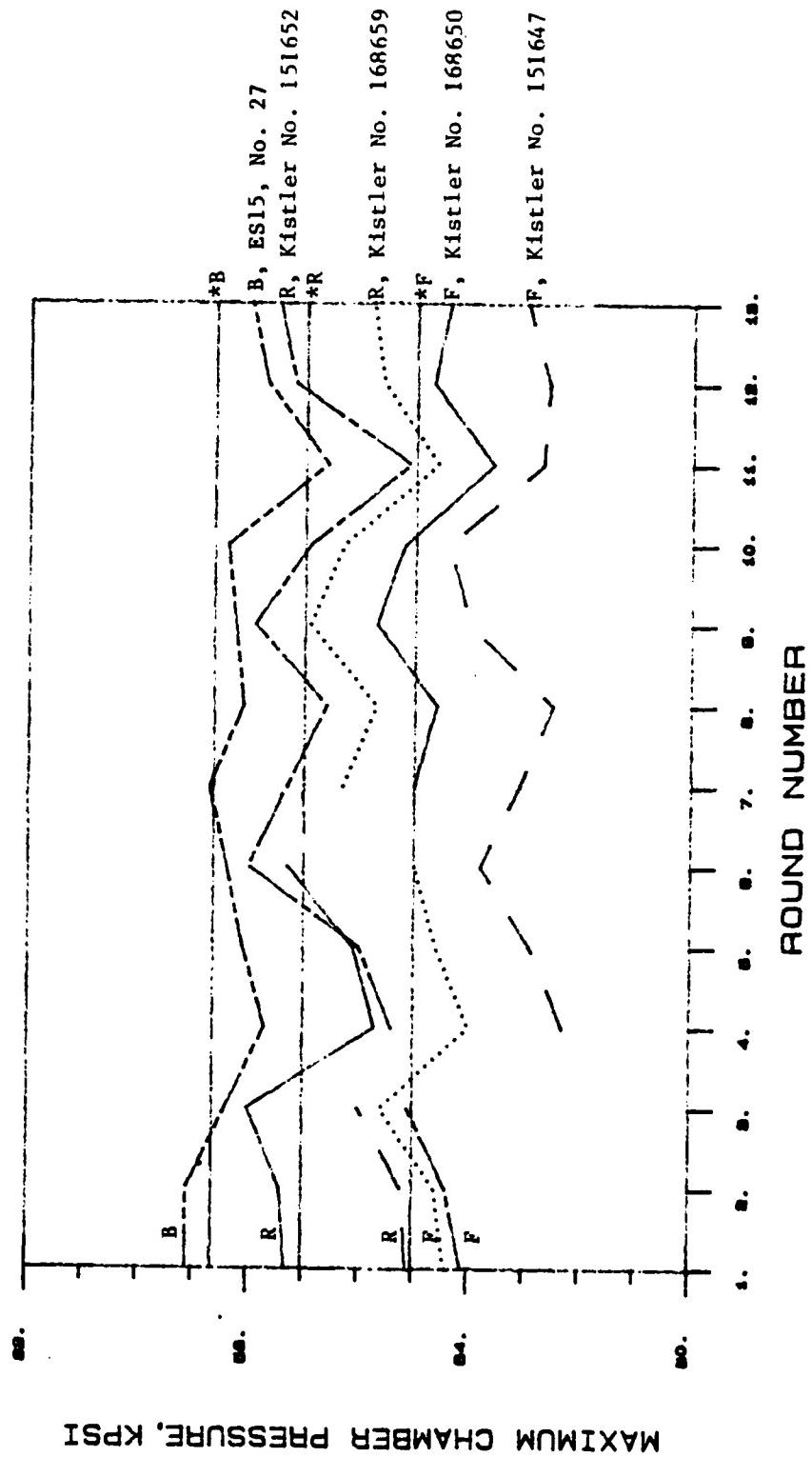
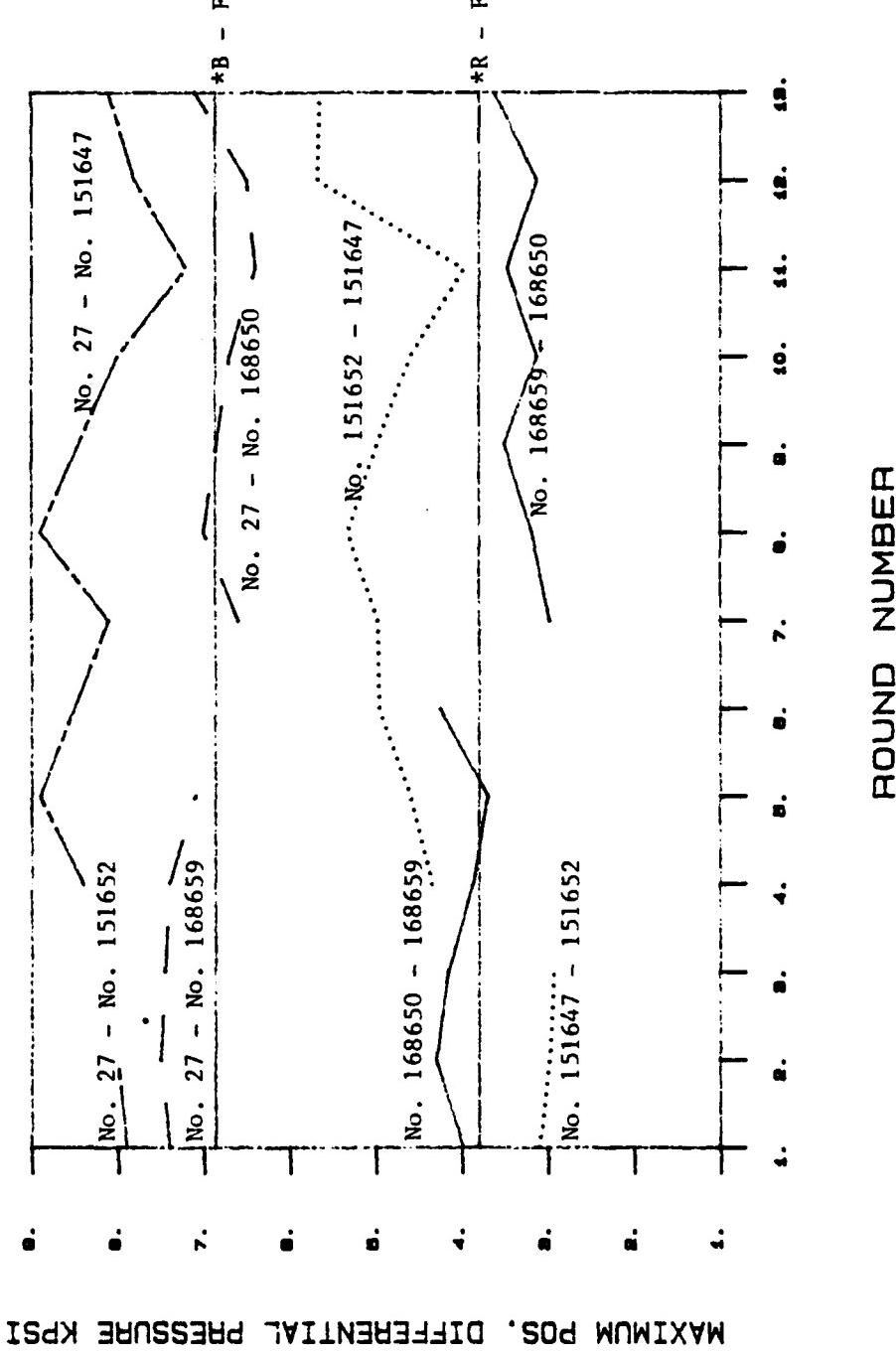


Figure 2.1-1(1). Maximum chamber pressure.

2.1 (Cont'd)

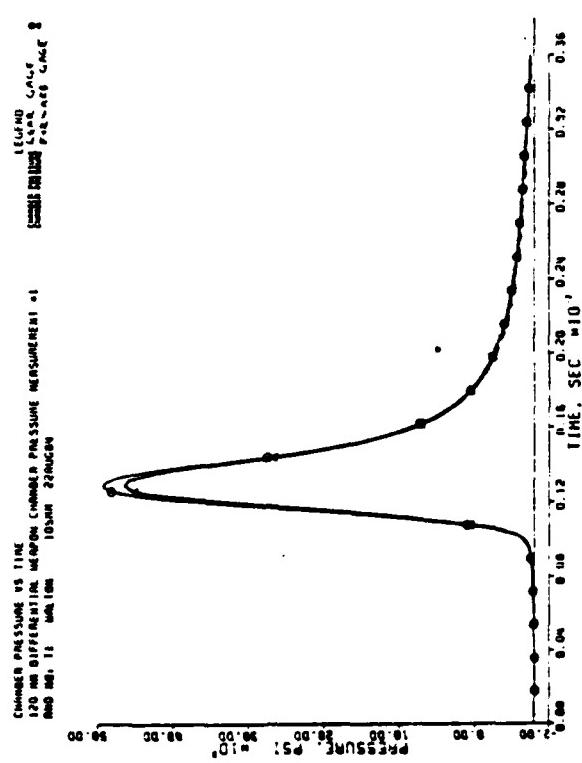
MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.  
 B - F = Base minus forward gage.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.1-1(2). Maximum positive differential pressure.

2.1 (Cont'd)



DIFFERENCE OF CHAMBER PRESSURE CHANNELS  
120 MM DIFFUSION, WEAPON CHAMBER PRESSURE MEASUREMENT #2  
RND NO. 11 WHT 10W 10MM 2PHASE

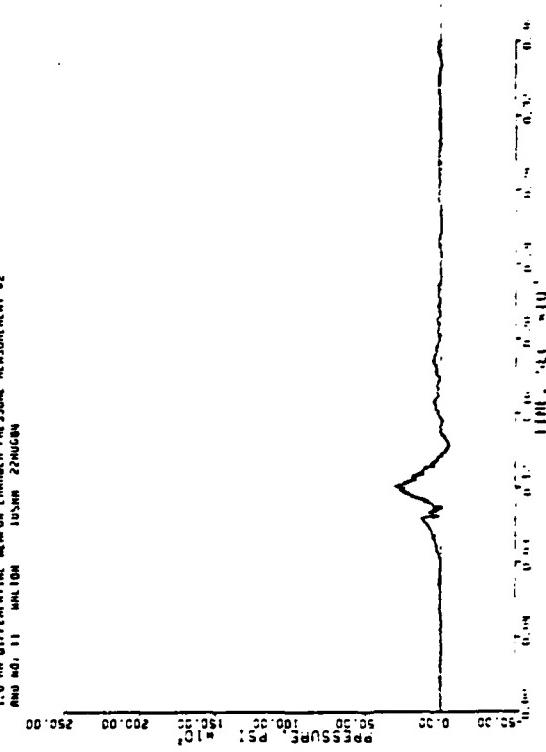


Figure 2.1-1a. Round No. 11.

2.1 (Cont'd)

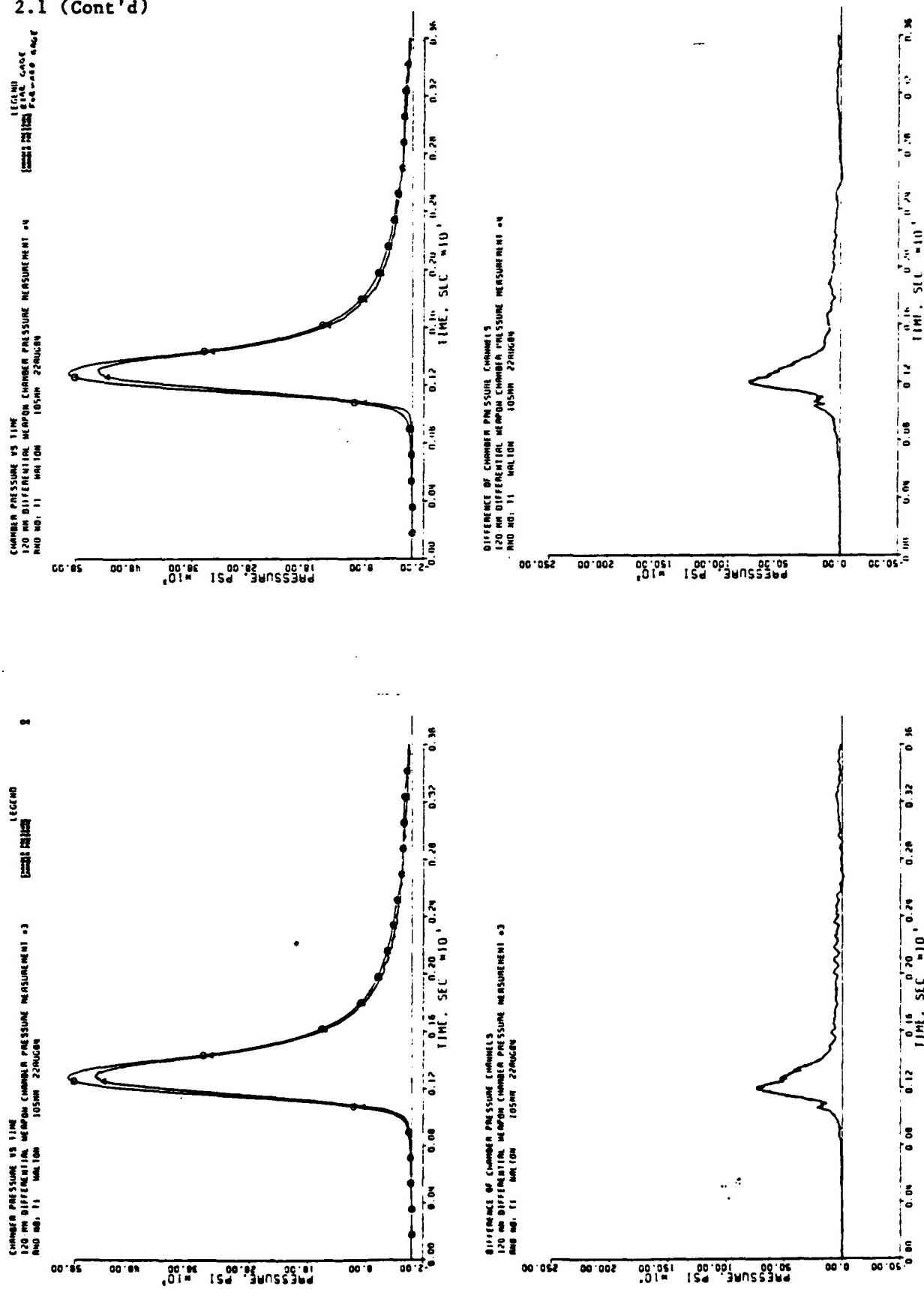


Figure 2.1-1b. Round No. T1.

2.1 (Cont'd)

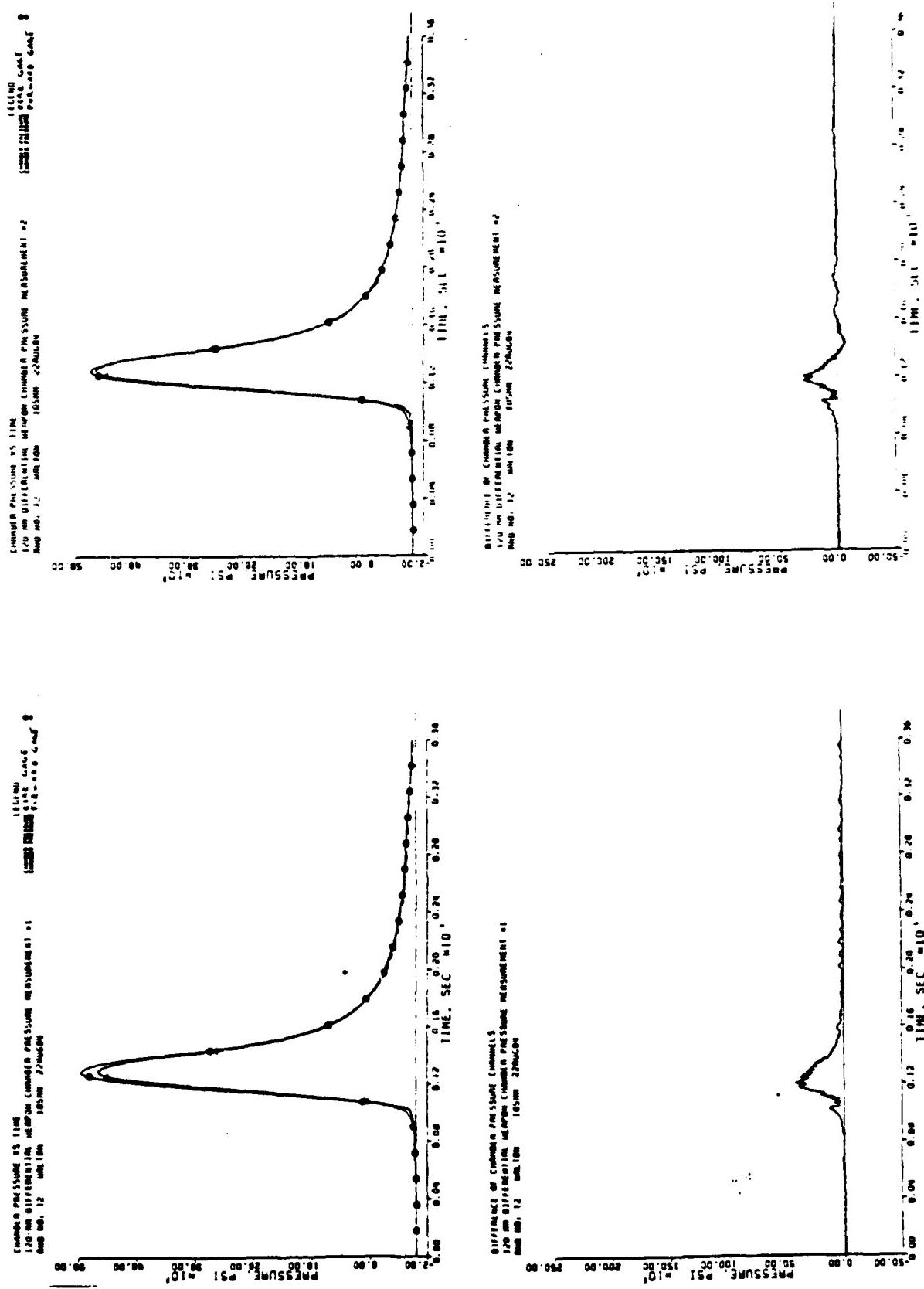


Figure 2.1-2a. Round No. T2.

2.1 (Cont'd)

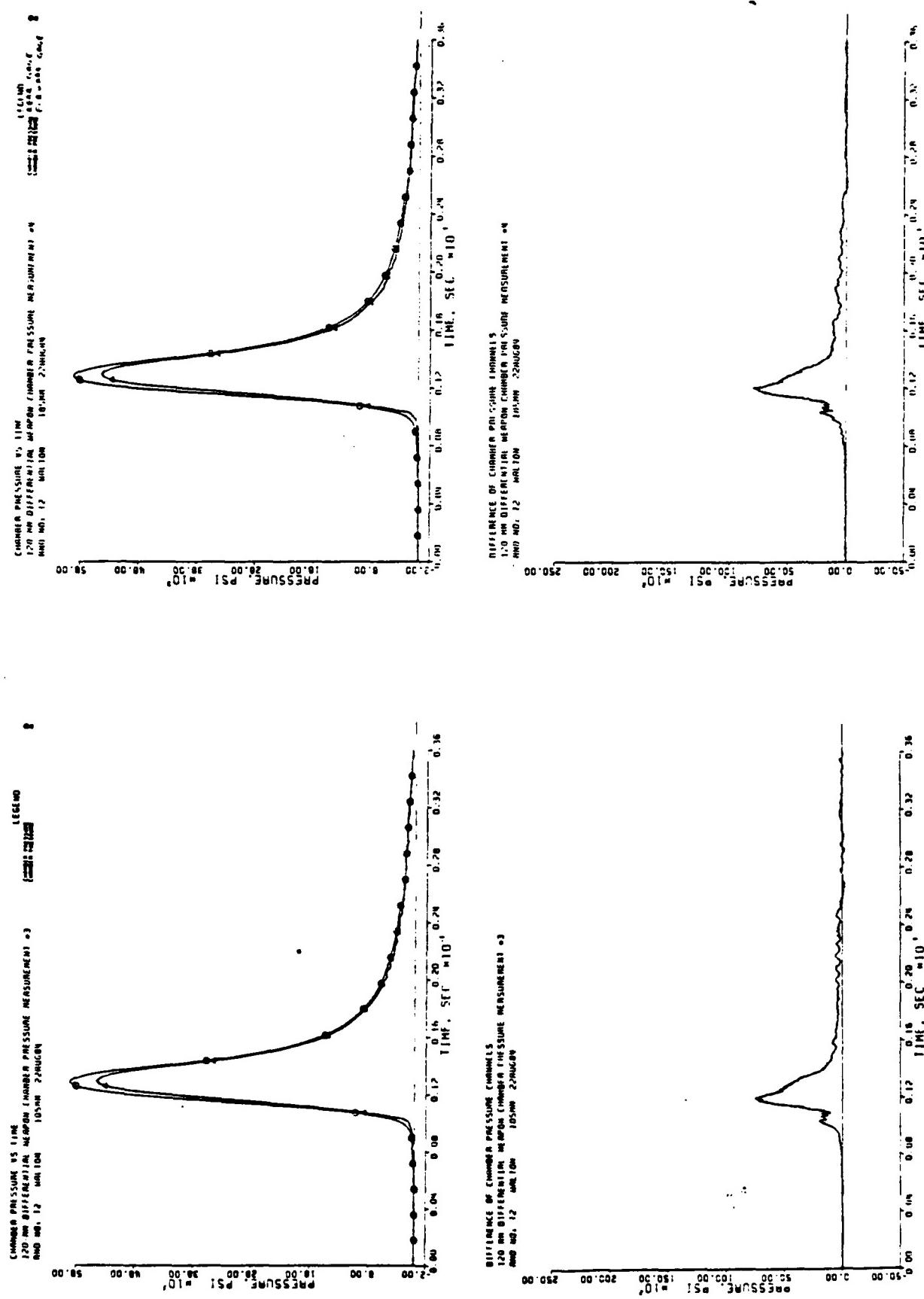


Figure 2.1-2b. Round No. T2.

2.1 (Cont'd)

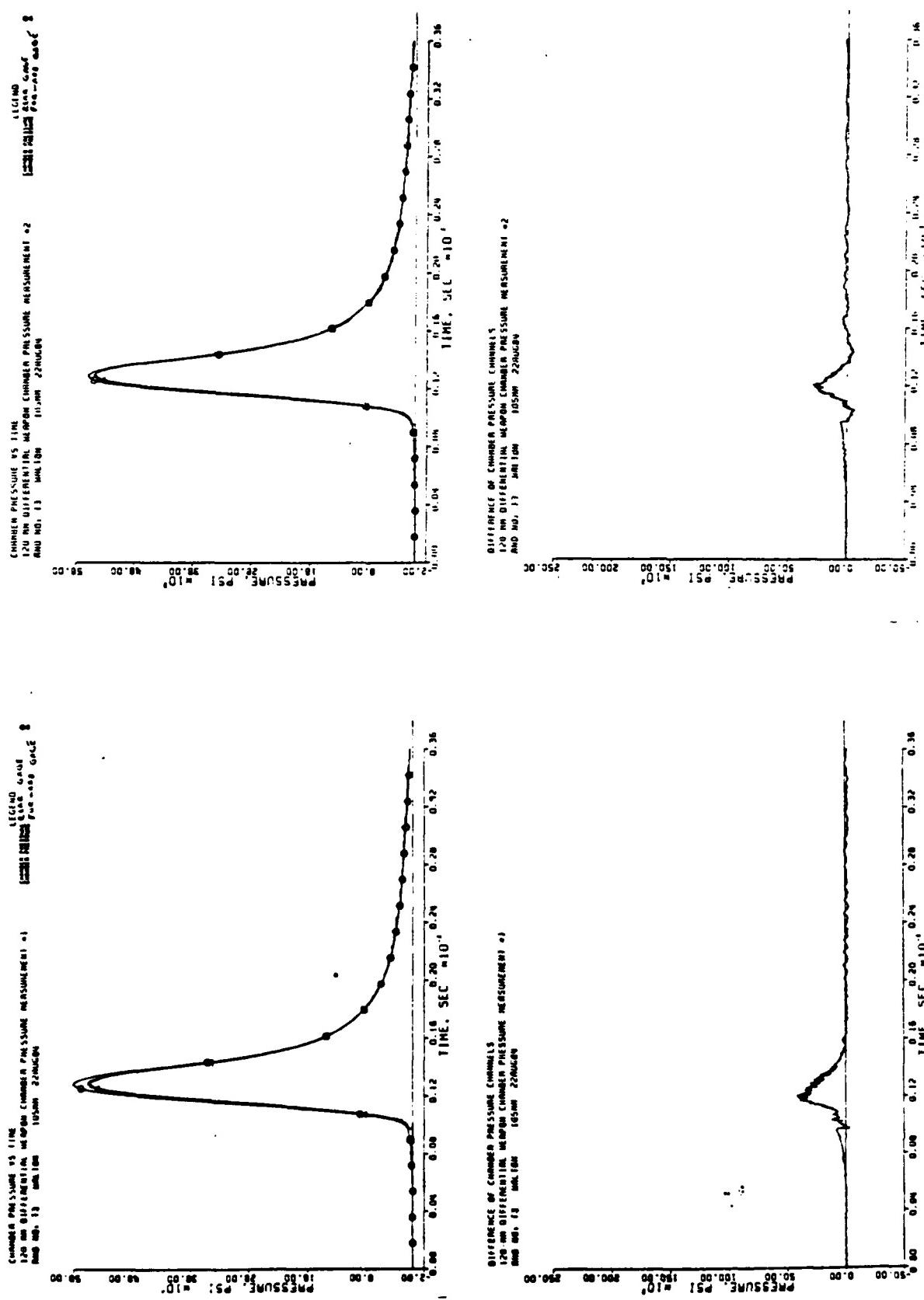


Figure 2.1-3. Round No. T3.

2.1 (Cont'd)

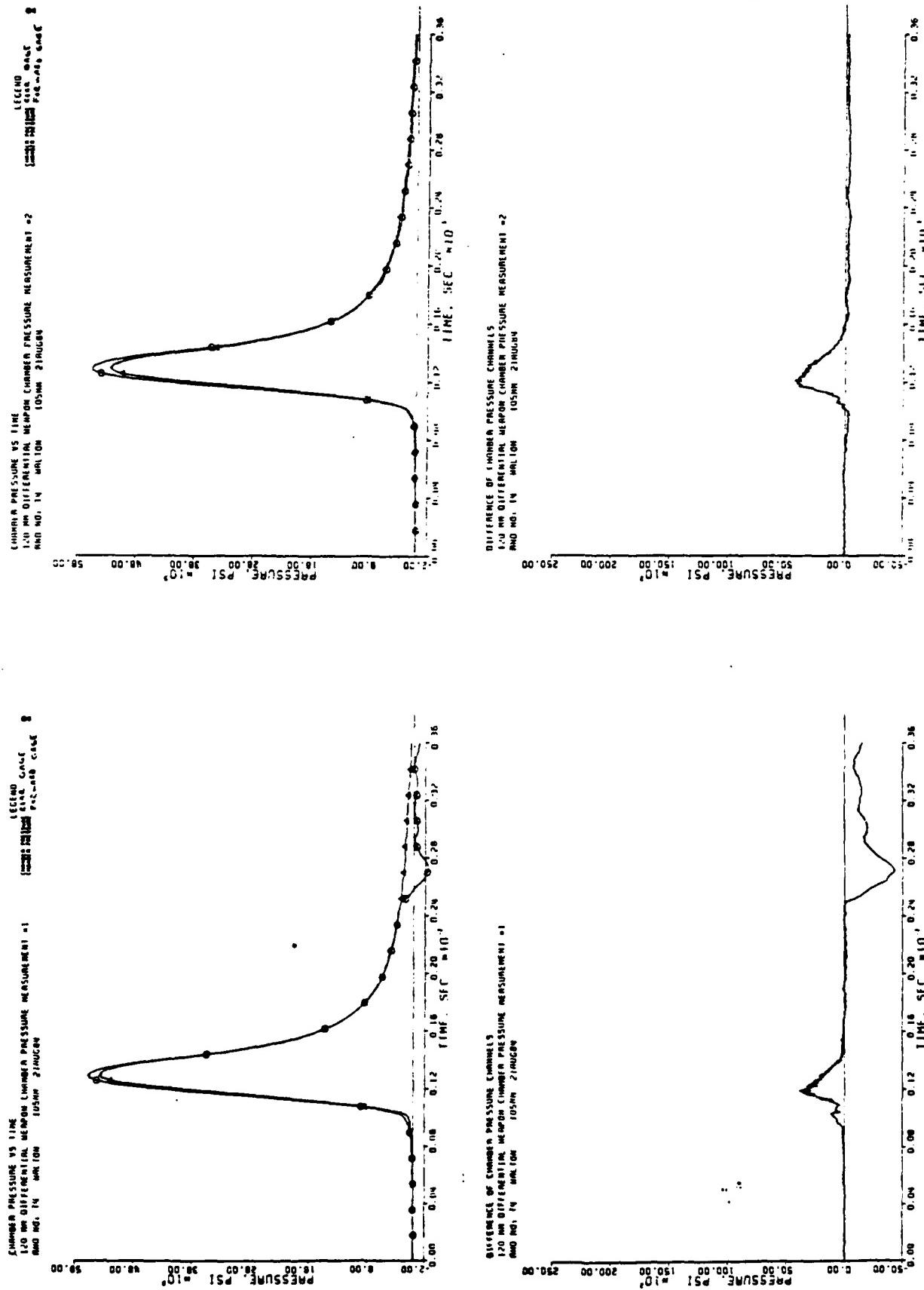


Figure 2.1-4a. Round No. T4.

2.1 (Cont'd)

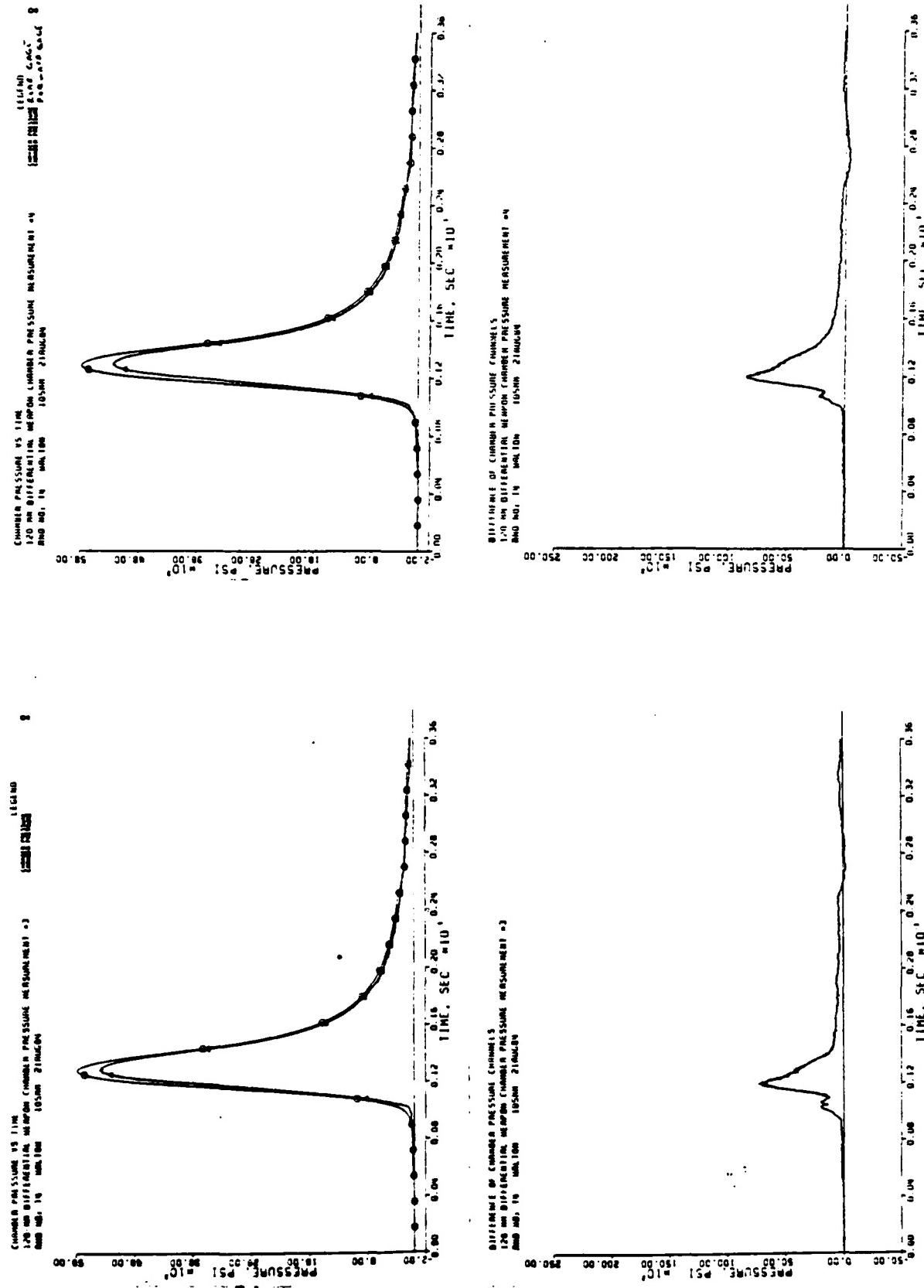


Figure 2.1-4b. Round No. T4.

2.1 (Cont'd)

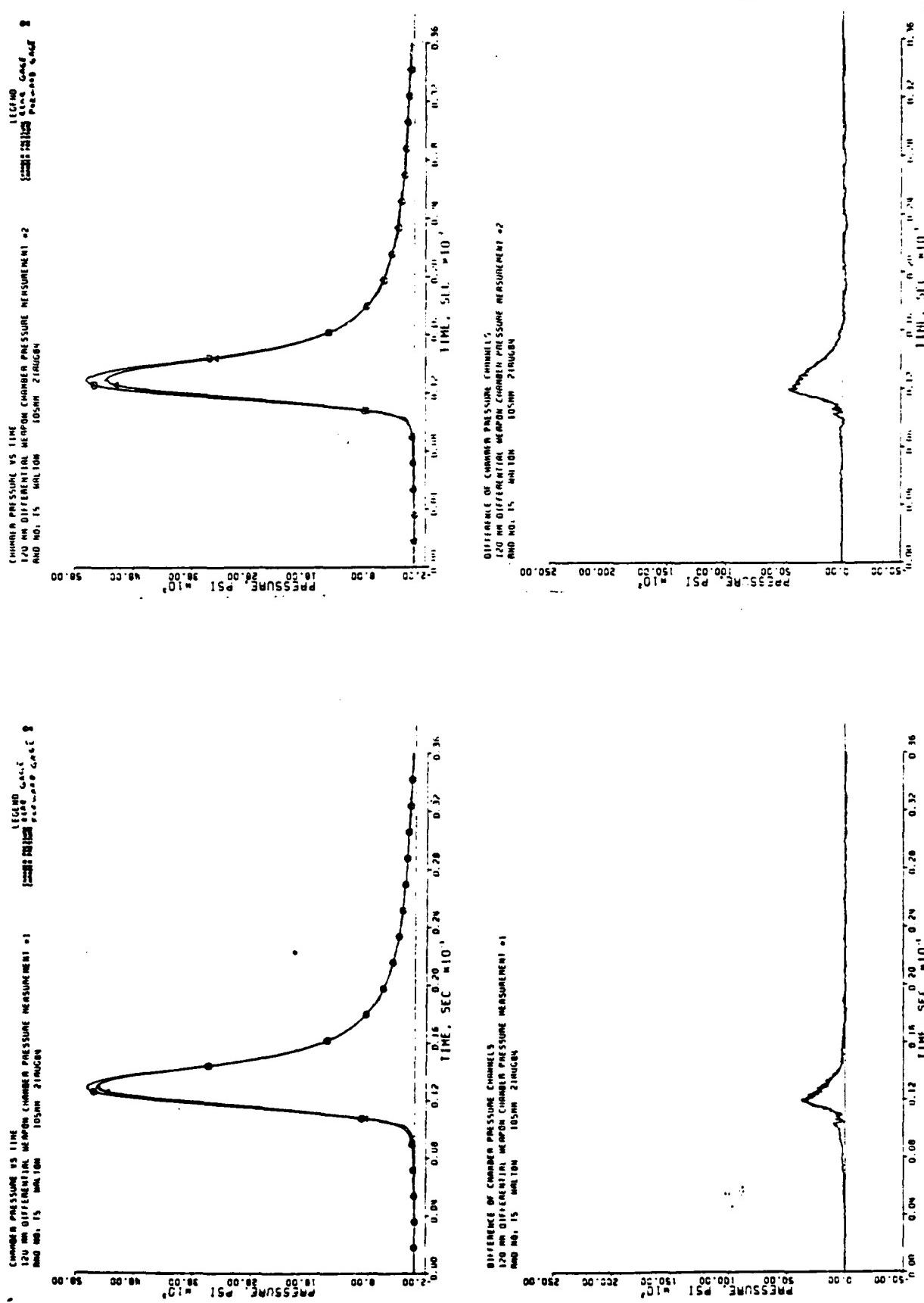


Figure 2.1-5a. Round No. T5.

## 2.1 (Cont'd)

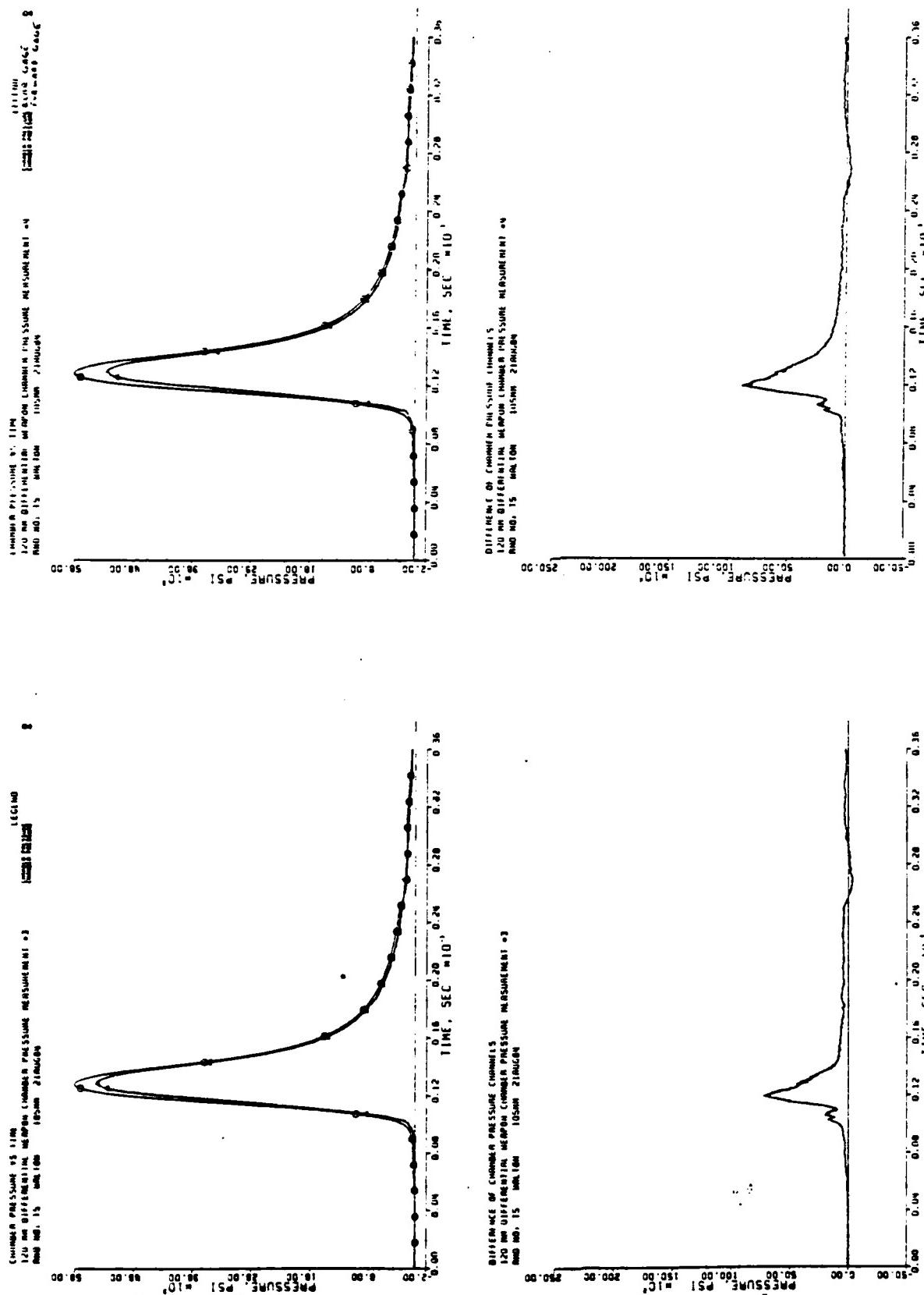


Figure 2.1-5b. — Round No. T5.

2.1 (Cont'd)

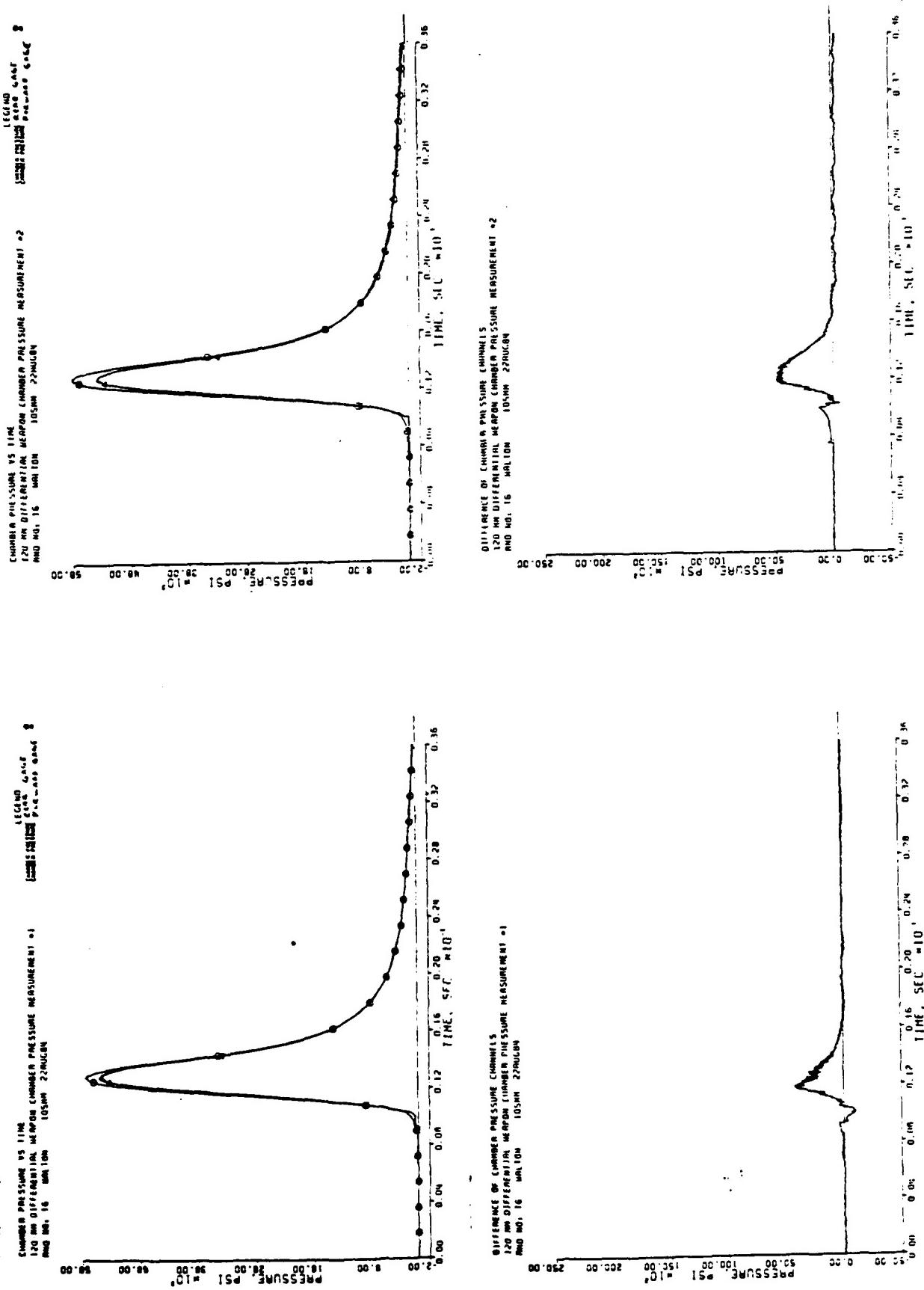


Figure 2.1-6. Round No. T6.

2.1 (Cont'd)

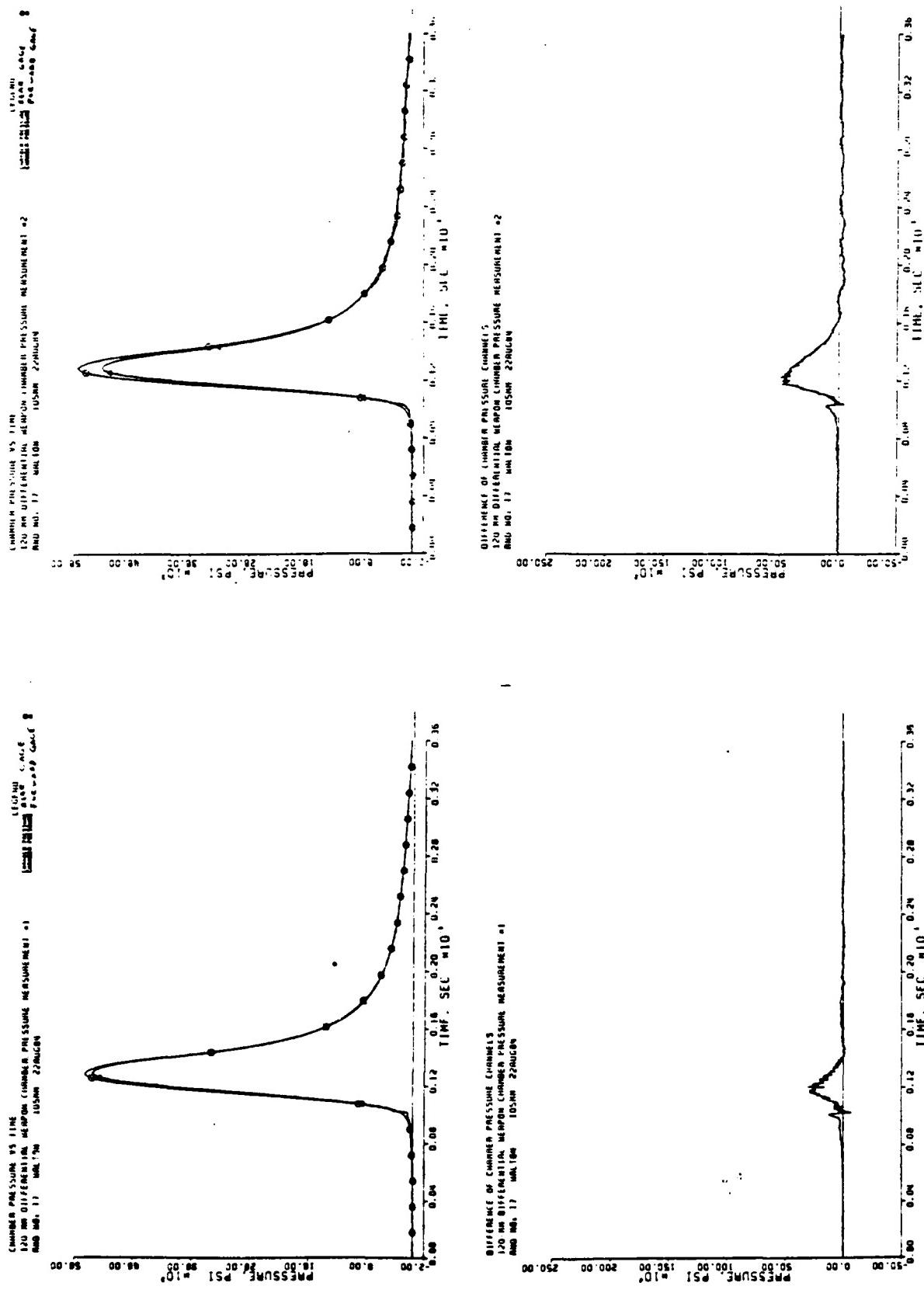


Figure 2.1-7a. Round No. T7.

105-mm Tank Gun  
Tube SN 25970  
Cartridge: M392A2  
Temperature: +70° F

TABLE 2-2-1. CHAMBER PRESSURE DATA - PHASE 1b

Ed No.	Ch 1	AMP Position	Ch 2	AMP Position	Ch 3	AMP Position	Ch 4	AMP Position	Ch 5	AMP Position	Maximum Chamber Pressure, kpsi		Maximum Initial +HP, psi	
											in Adapter No. 1		in Adapter No. 2	
											Gage	Base	Gage	Base
<b>Date fired: 23 August 1984</b>														
T214	56.8	316	Rear	55.8	316	Forward	55.2	316	Rear	54.3	316	Forward	58.6	316
T215	56.7	316	Rear	55.8	316	Forward	55.2	316	Rear	54.5	316	Forward	58.6	316
T216	57.4	316	Rear	457.6	316	Forward	56.3	316	Rear	54.9	316	Forward	56.0	316
T17	56.6	316	Rear	55.0	316	Forward	54.9	316	Forward	56.0	316	Rear	58.0	316
T18	55.5	316	Rear	54.3	316	Forward	54.4	316	Forward	55.4	316	Rear	57.6	316
T19	57.6	316	Rear	56.3	316	Forward	56.0	316	Forward	57.4	316	Rear	58.0	316
T20	55.8	316	Forward	58.2	316	Rear	56.2	316	Forward	57.2	316	Rear	59.5	316
<b>Date fired: 24 August 1984</b>														
T21	54.8	316	Forward	57.7	316	Rear	55.1	316	Forward	57.2	316	Rear	58.9	316
T22	55.9	316	Forward	58.8	316	Rear	56.1	316	Forward	57.7	316	Rear	59.3	316
T23	55.5	504	Forward	58.5	316	Rear	56.0	504	Forward	57.4	316	Rear	59.1	316
T24	55.6	504	Forward	58.1	316	Rear	55.4	504	Forward	57.2	316	Rear	59.1	316
T25	54.9	316	Forward	57.4	504	Rear	54.2	316	Forward	57.6	504	Rear	58.6	316
T26	54.4	316	Forward	57.2	504	Rear	55.3	316	Forward	57.7	504	Rear	58.4	316

\*Forward peak pressure greater than rear peak pressure, oscillation occurs at peak.

NA = Not applicable.

NR = Not recorded.

Ch = Channel.

## 2.2 PHASE Ib. ROUNDS 14 THROUGH 26, TUBE 25970

Yuma ES15 gages were mounted in adapters No. 1 and 2 in the right side of the tube, and Kistler 6211 gages were mounted without adapters in the left side of the tube. Kistler gages No. 168650 and 168659 used in this phase were the same gages used in the right side of the tube during the previous phase.

The ES15 differential pressure plots exhibit a pronounced high frequency oscillation after peak pressure, as shown in the plot for round 18. Peak differential pressures range from 2800 to 4700 psi, which is within expected results. These differentials compare favorably with the Kistler 6211 differential peaks, seldom varying more than 600 psi. There are no crossover effects, and the majority of the differential plots return to zero baseline in the expected manner. Rounds 21, 25, and 26 exhibit a positive offset. The ES15 gages were reversed before round 20 and charge amplifiers were changed before round 25.

The Kistler 6211 gages produce good results until round 23 when the differential plots begin passing through zero and go negative. On rounds 25 and 26, a severe positive offset occurs. While this may be the result of changing charge amplifiers, the offsets in Phase Ia were not nearly as large when charge amplifiers were changed. The positive offsets on rounds 25 and 26 do not appear to seriously affect the positive differential peak pressure. Prior to round 25, differential pressures varied from approximately 3000 to 3800 psi. Differential pressures for rounds 25 and 26 were 4400 and 4100 psi, respectively. It appears from these limited data that differential peak pressures can be used in the presence of a zero offset.

Differential pressures produced by the forward and base gage combinations show a characteristic dip at approximately 25 milliseconds. This is attributed to motion of the coaxial cable attached to the base gage. The base-forward positive peak differential pressures are approximately 2500 psi higher than peaks produced by the rear-forward gage positions. Several significant zero offsets occur in the differential plots for the base and forward ES15 gage pair.

When the base ES15 gage is compared to the forward Kistler gage on the left side of the gun, a positive zero offset is evident throughout all records in this phase. The more severe offsets on rounds 25 and 26 do not result in peak pressures which deviate significantly from previous records. It again appears that the peak pressure in a plot of differential pressure is not made unusable by the failure of the plot to return immediately to zero baseline.

2.1 (Cont'd)

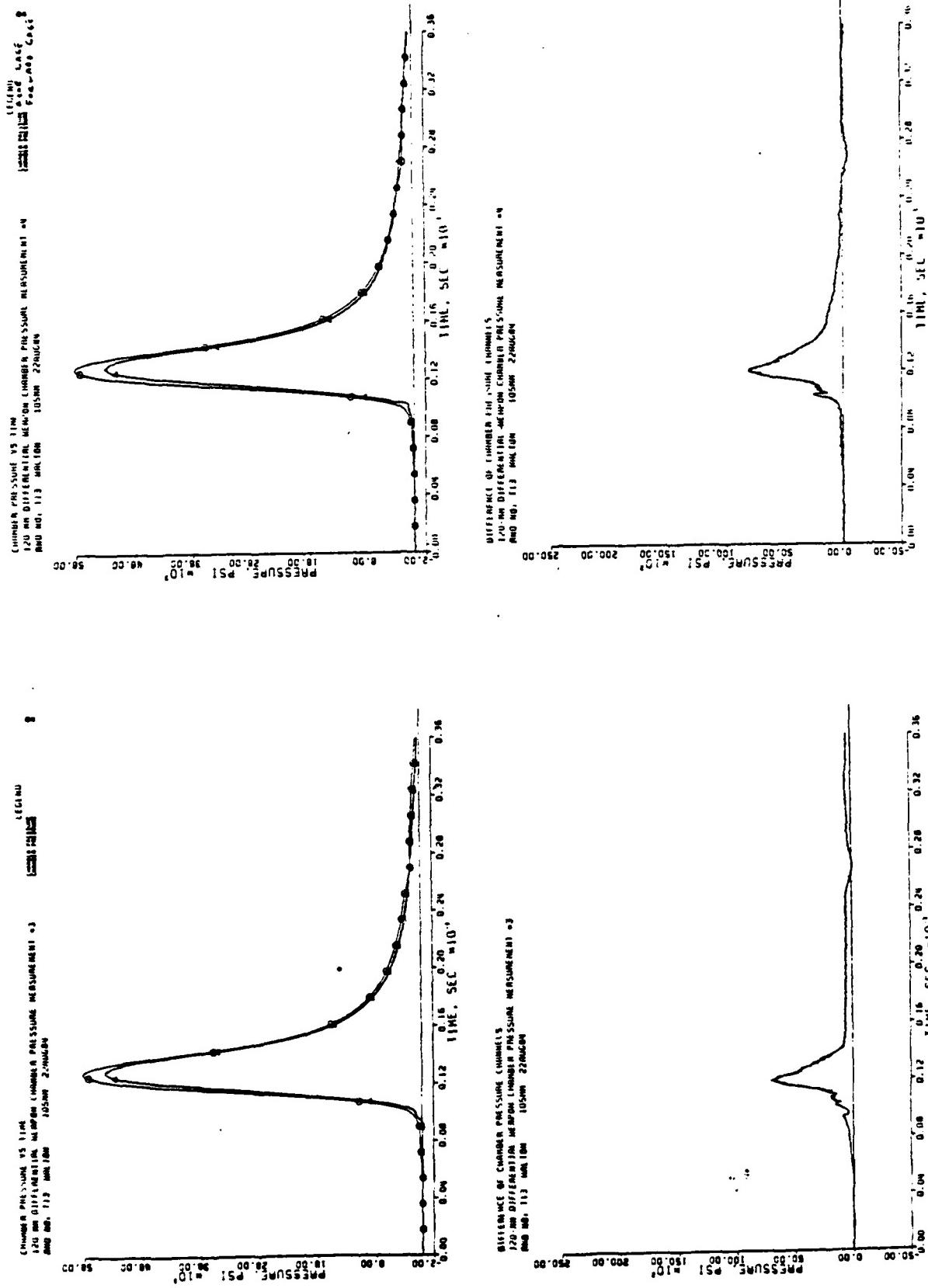


Figure 2.1-13b. Round No. T13.

2.1 (Cont'd)

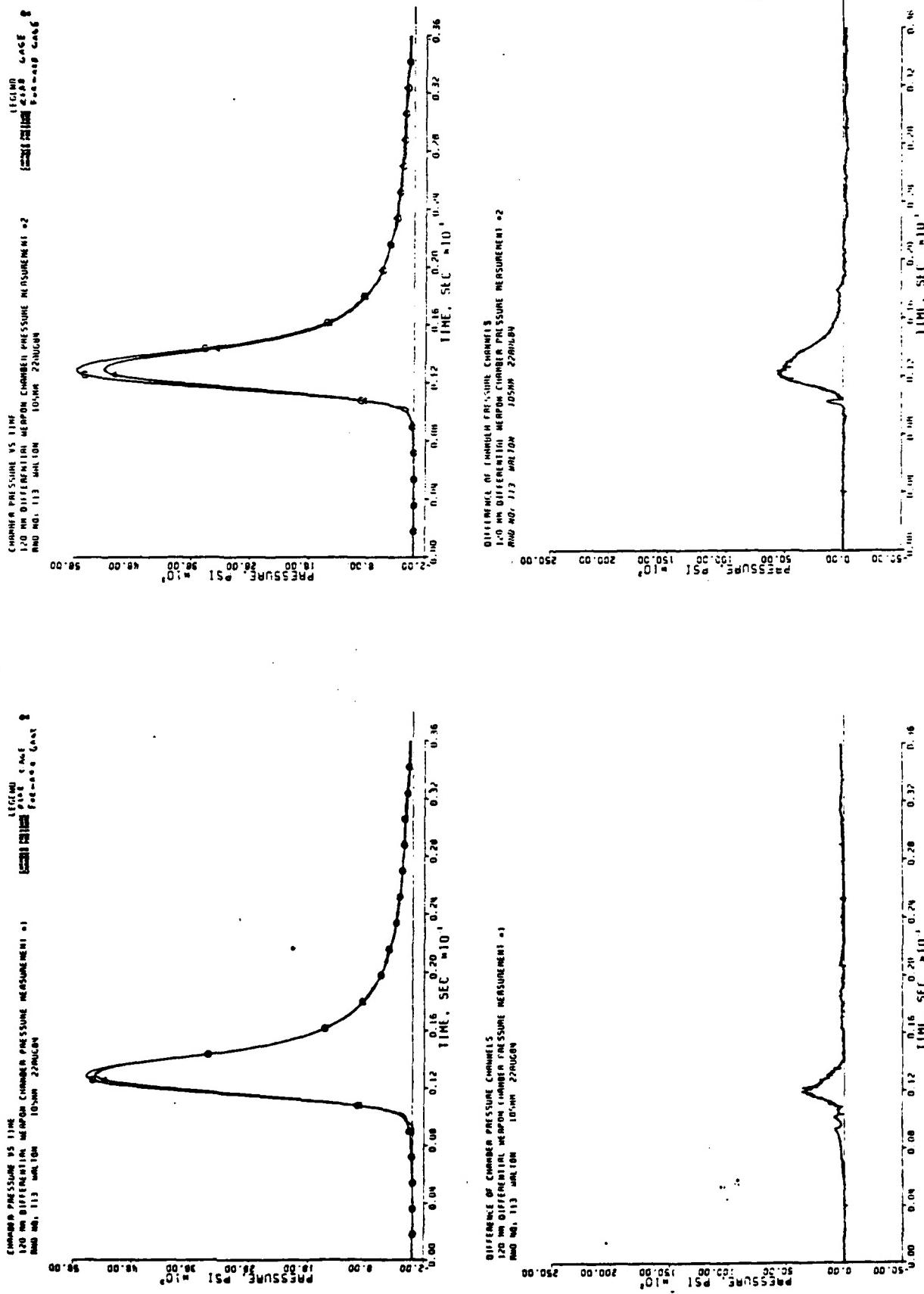


Figure 2.1-13a. Round No. 113.

2.1 (Cont'd)

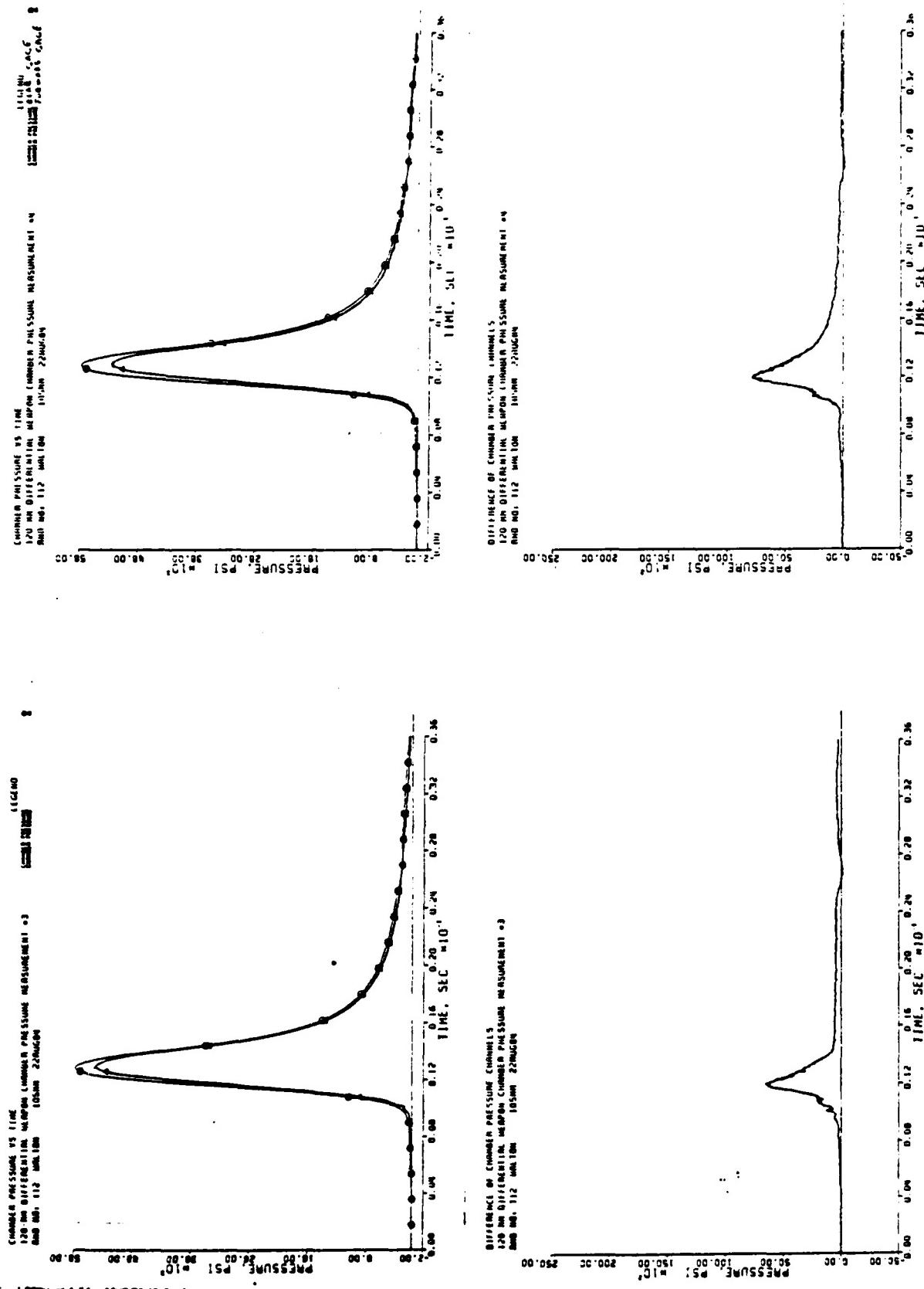


Figure 2.1-12b. Round No. T12.

## 2.1 (Cont'd)

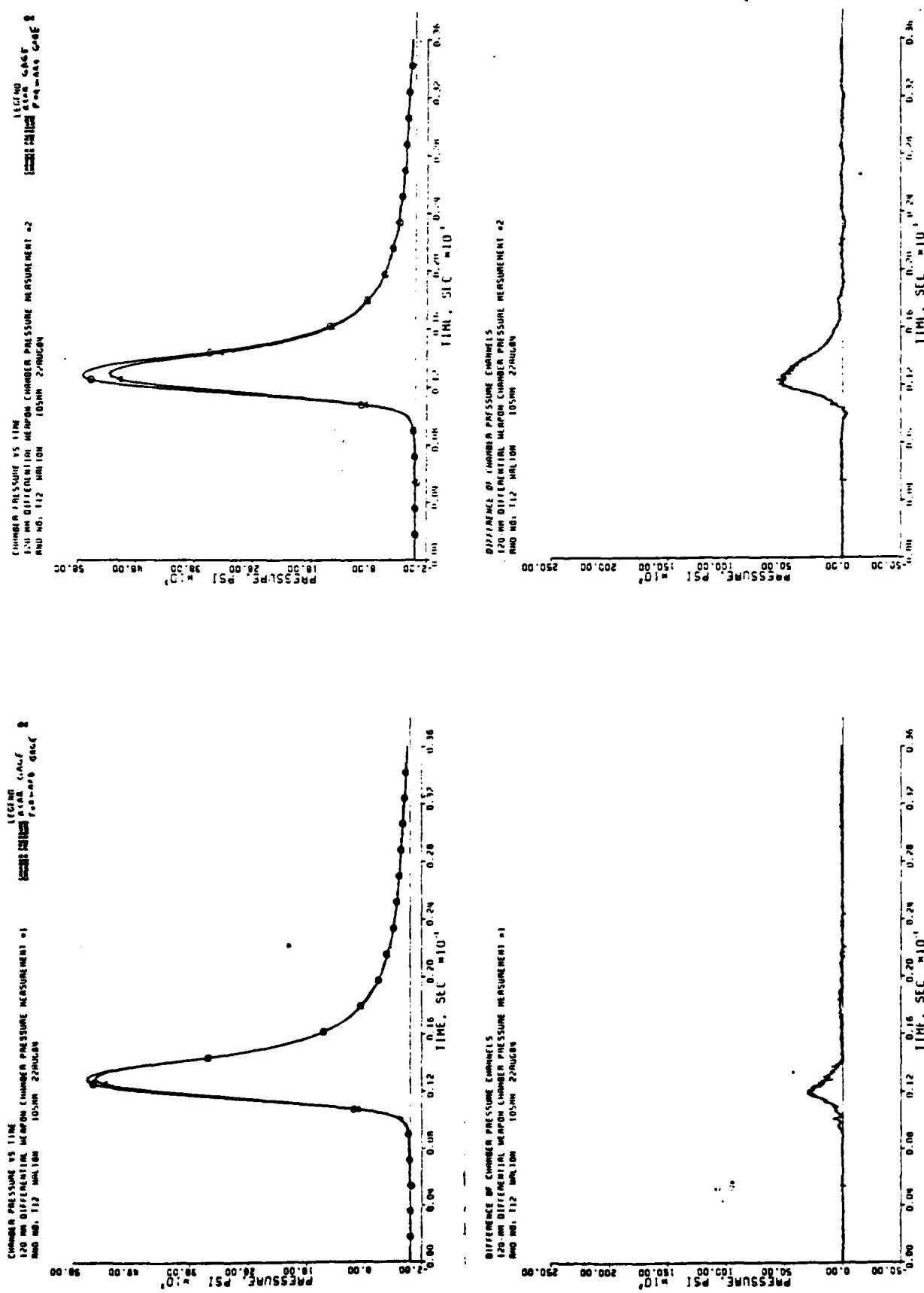


Figure 2.1-12a. Round No. T12.

2.1 (Cont'd)

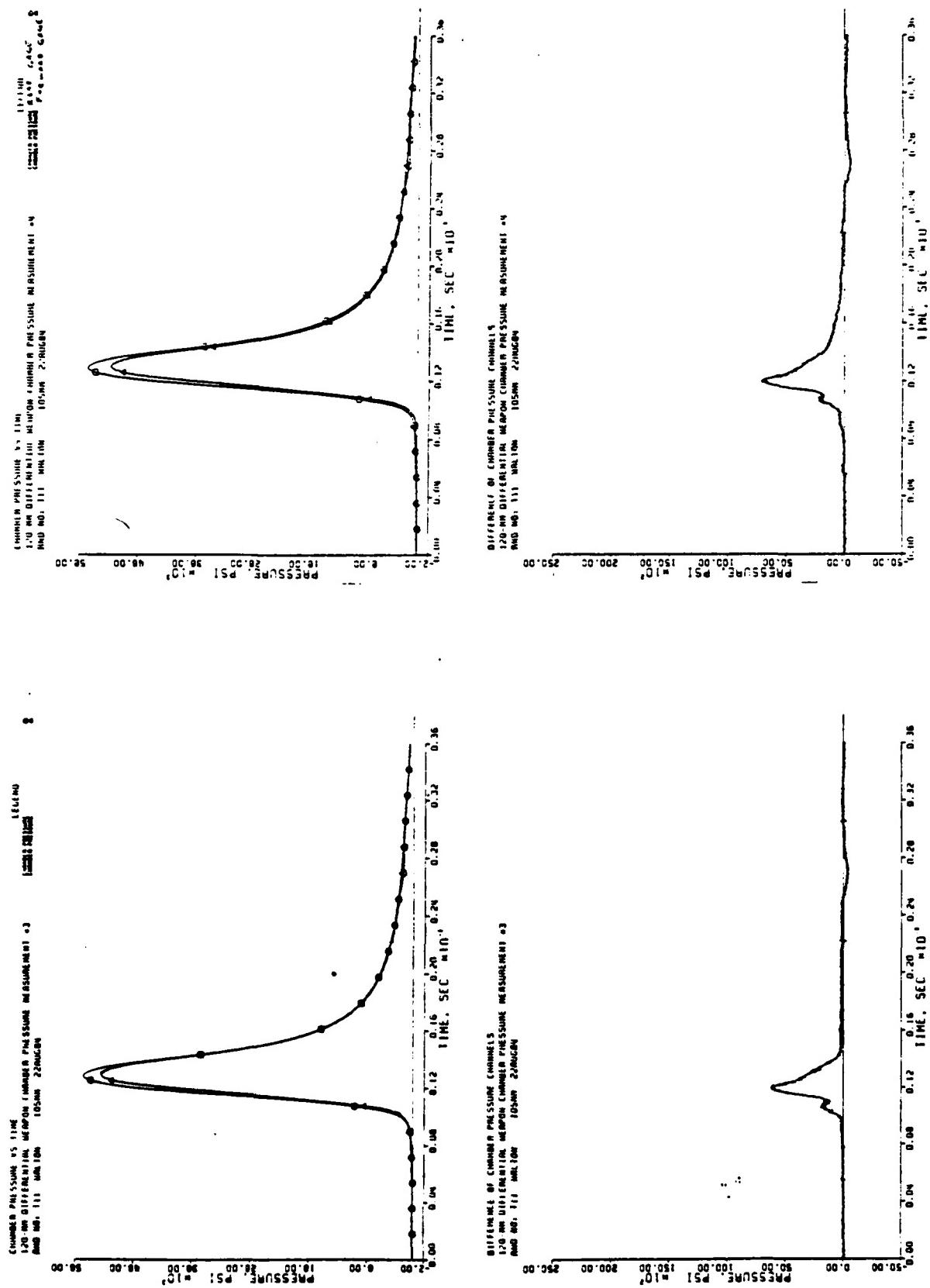


Figure 2.1-11b. Round No. 111.

2.1 (Cont'd)

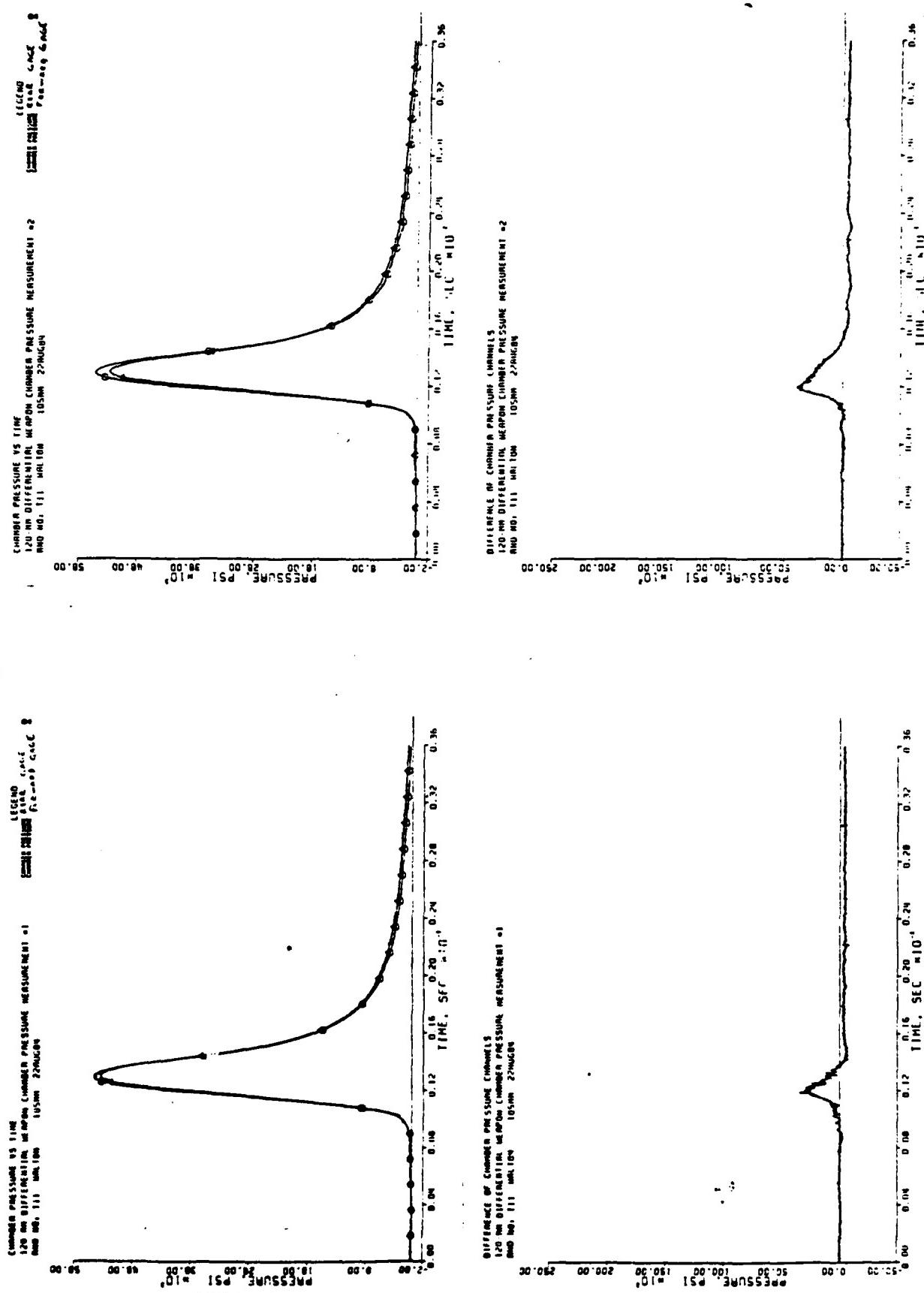


Figure 2.1-11a. — Round No. T11.

2.1 (Cont'd)

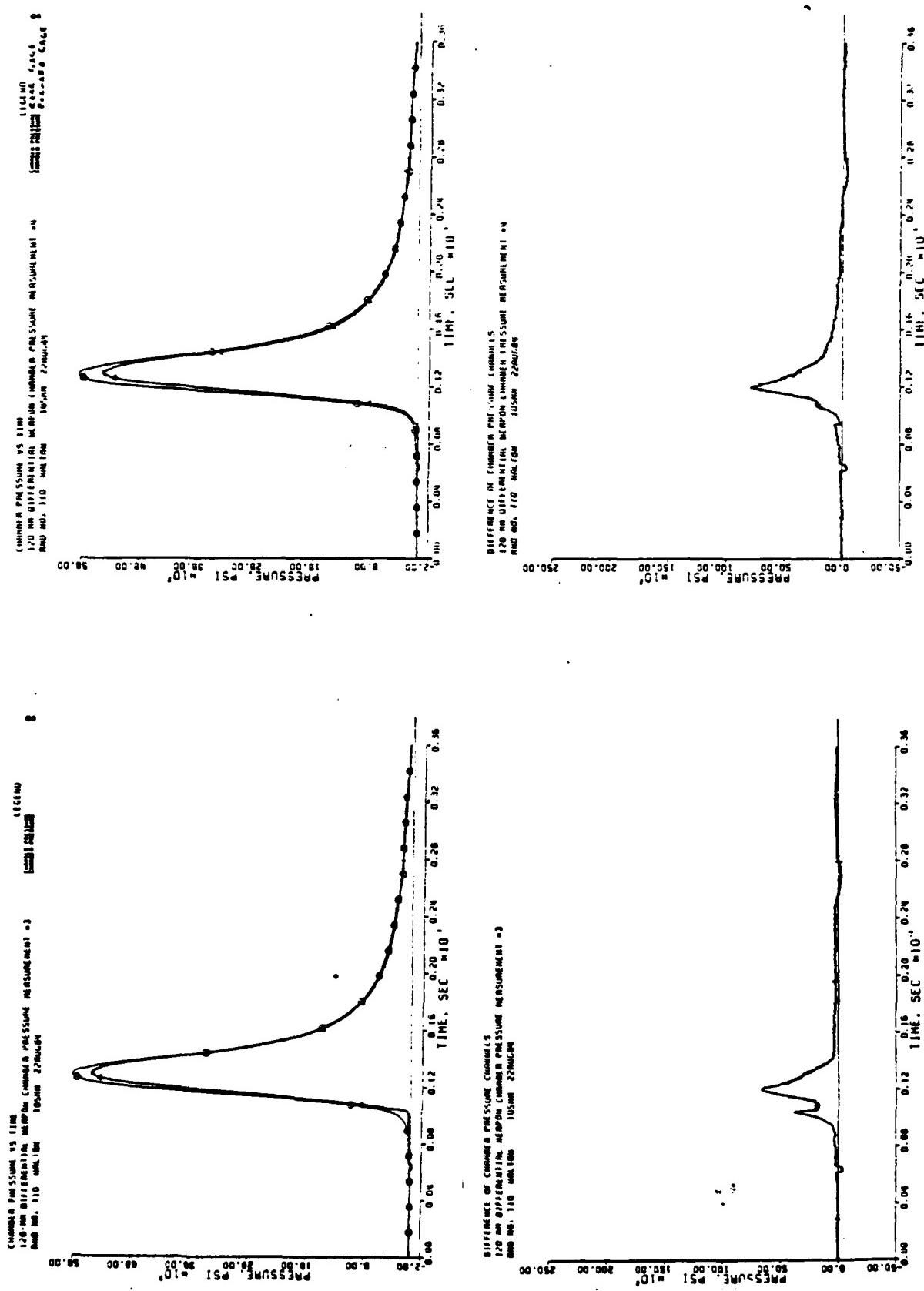


Figure 2.1-10b. Round No. T10.

2.1 (Cont'd)

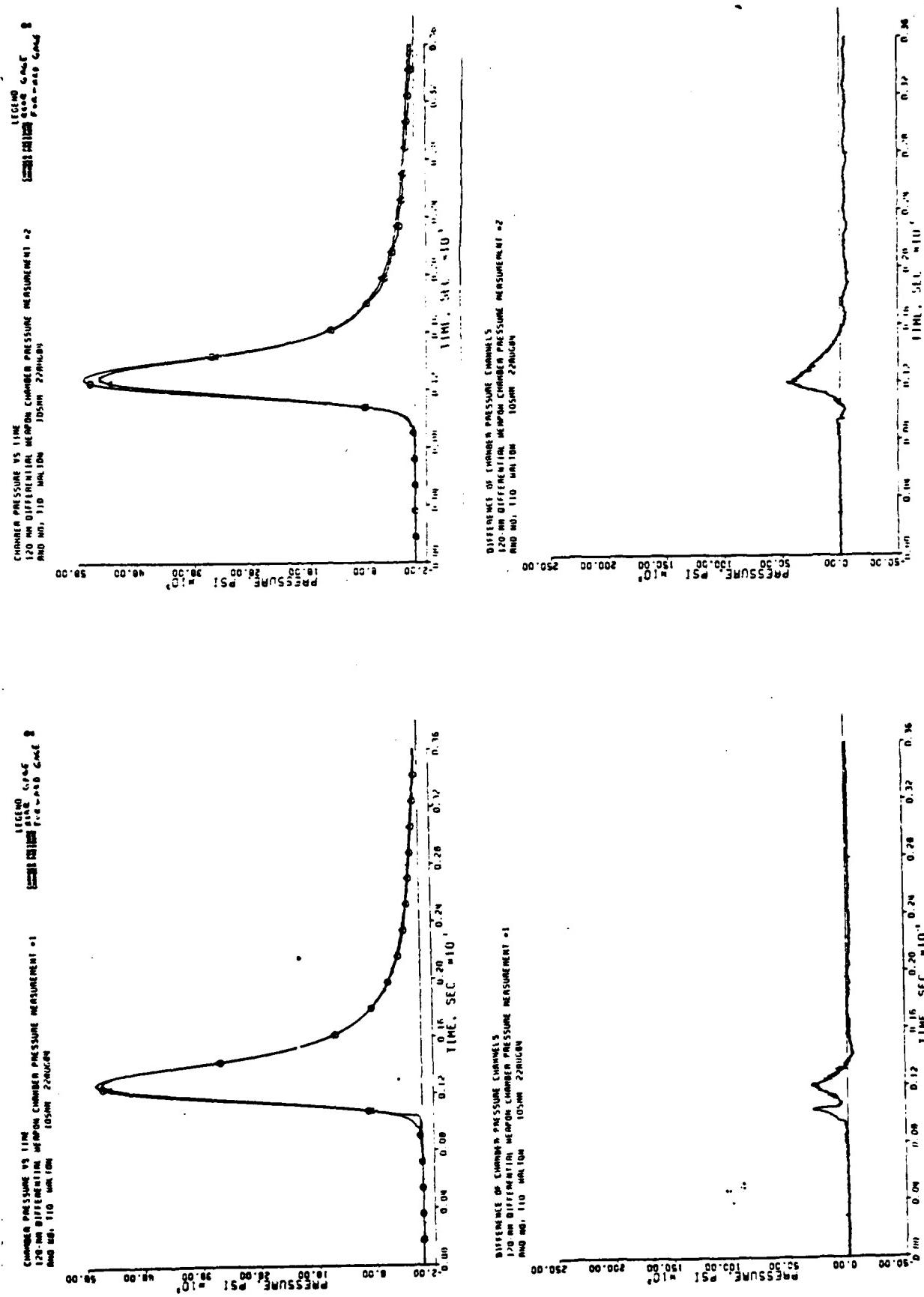


Figure 2.1-10a. — Round No. T10.

2.1 (Cont'd)

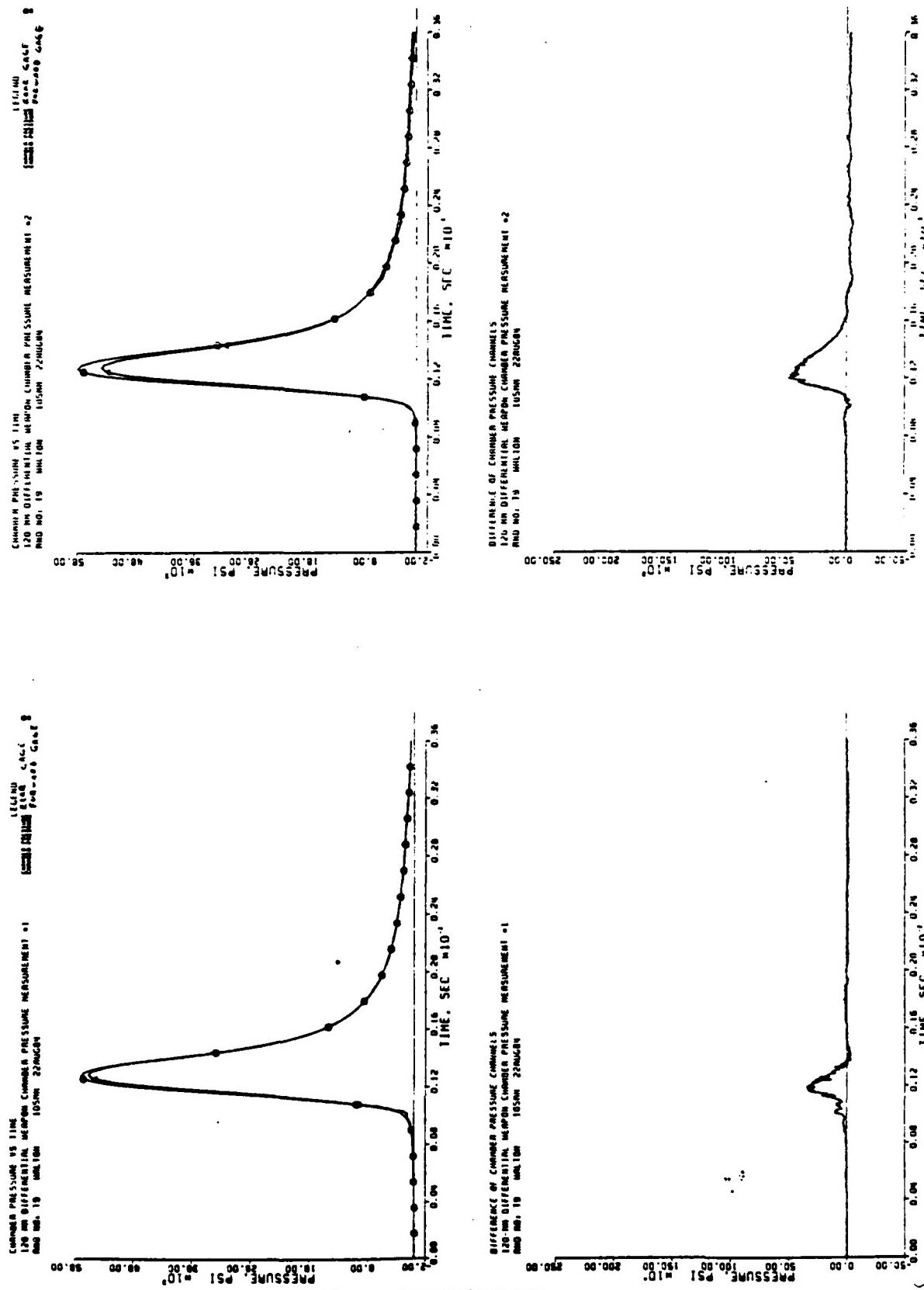


Figure 2.1-9. Round No. 19.

2.1 (Cont'd)

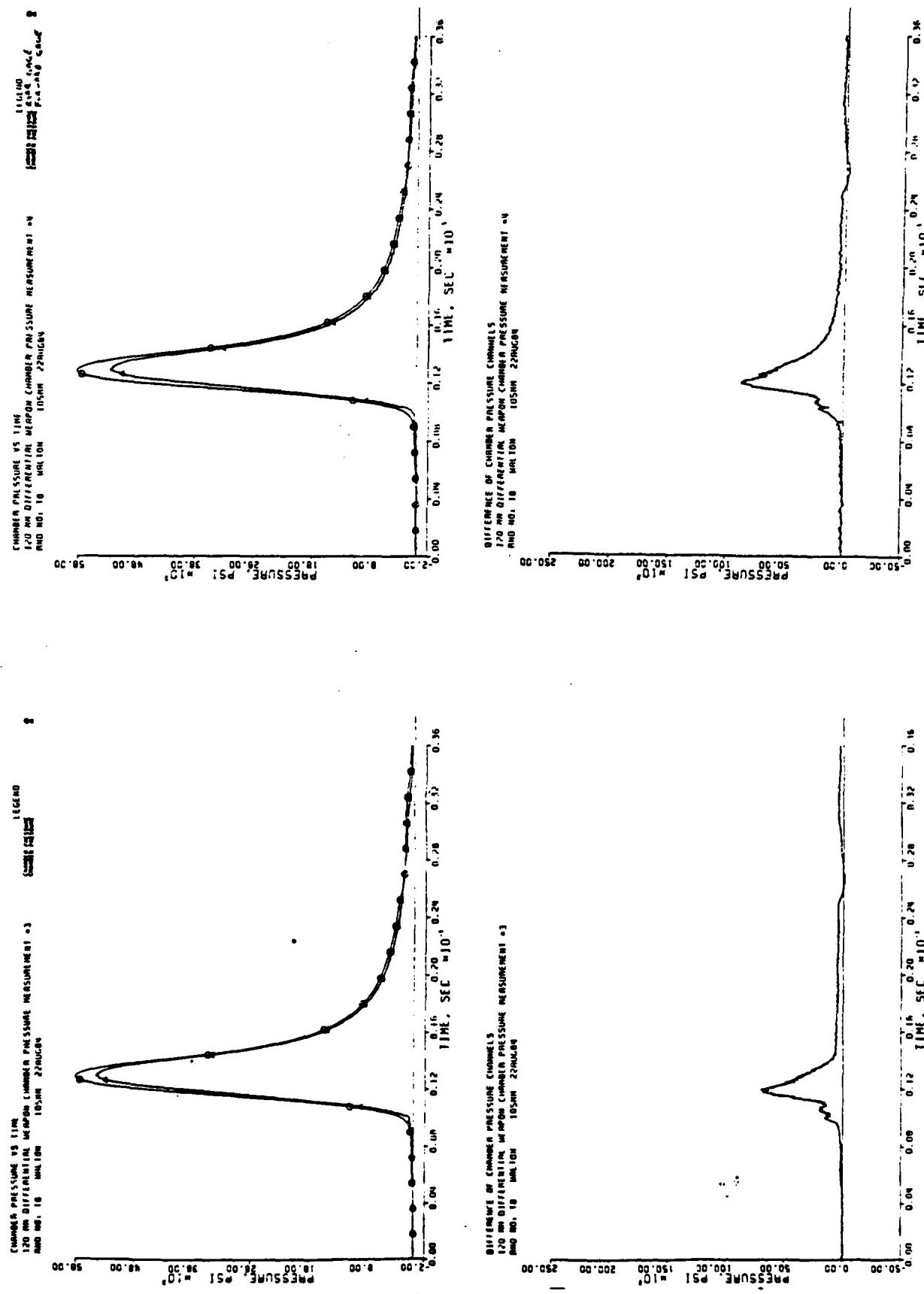


Figure 2.1-8b. Round No. 18.

2.1 (Cont'd)

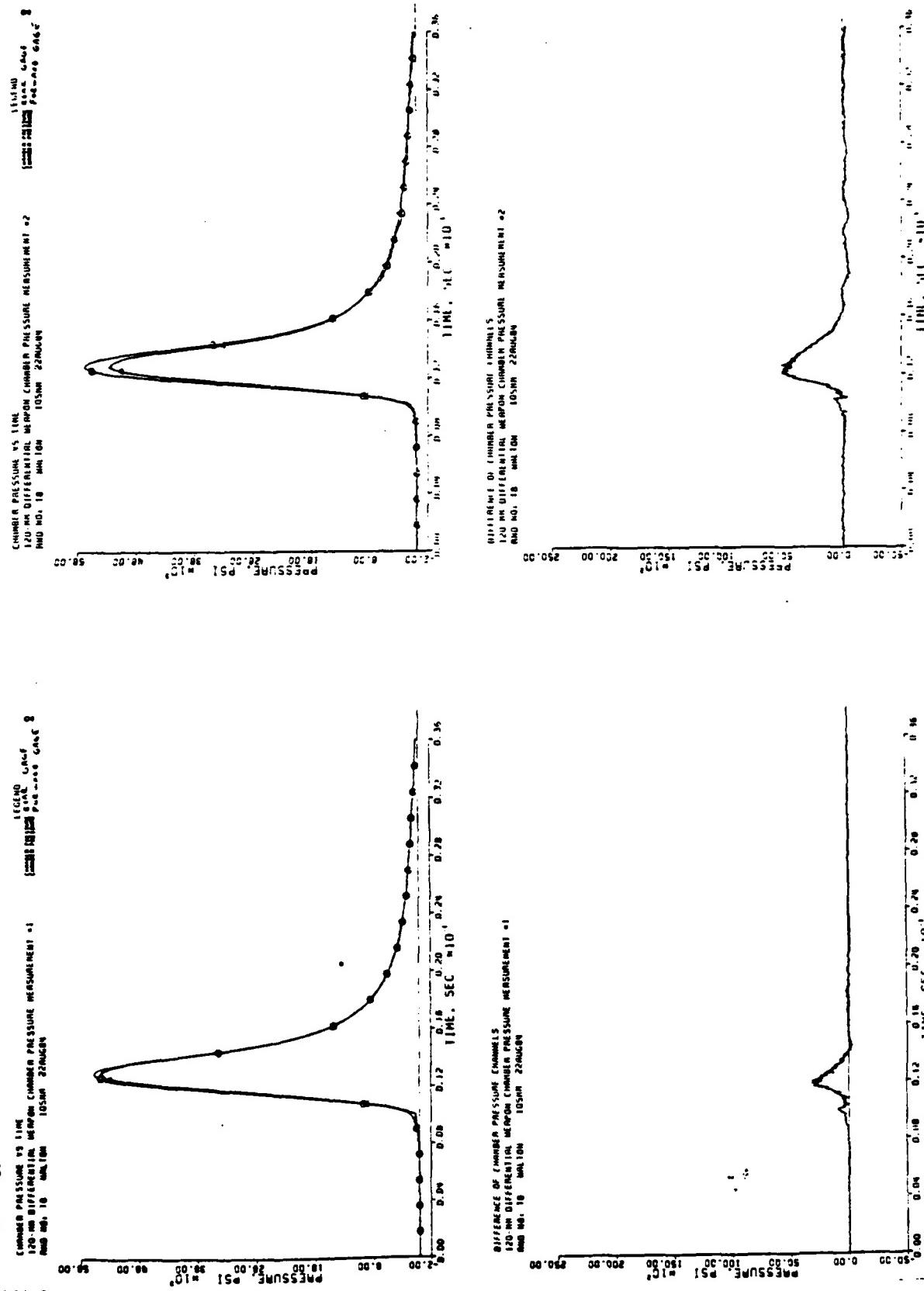


Figure 2.1-8a. Round No. T8..

2.1 (Cont'd)

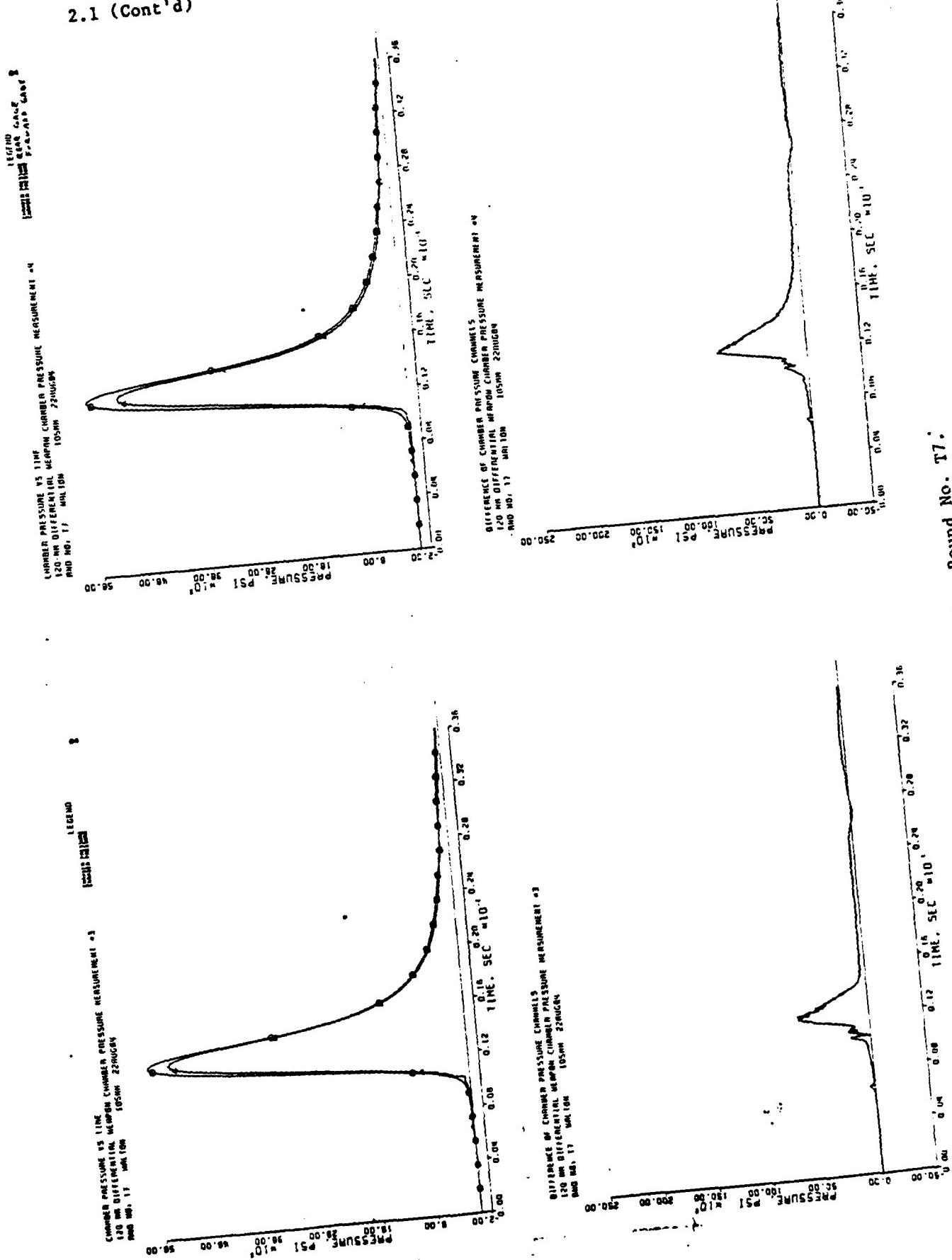
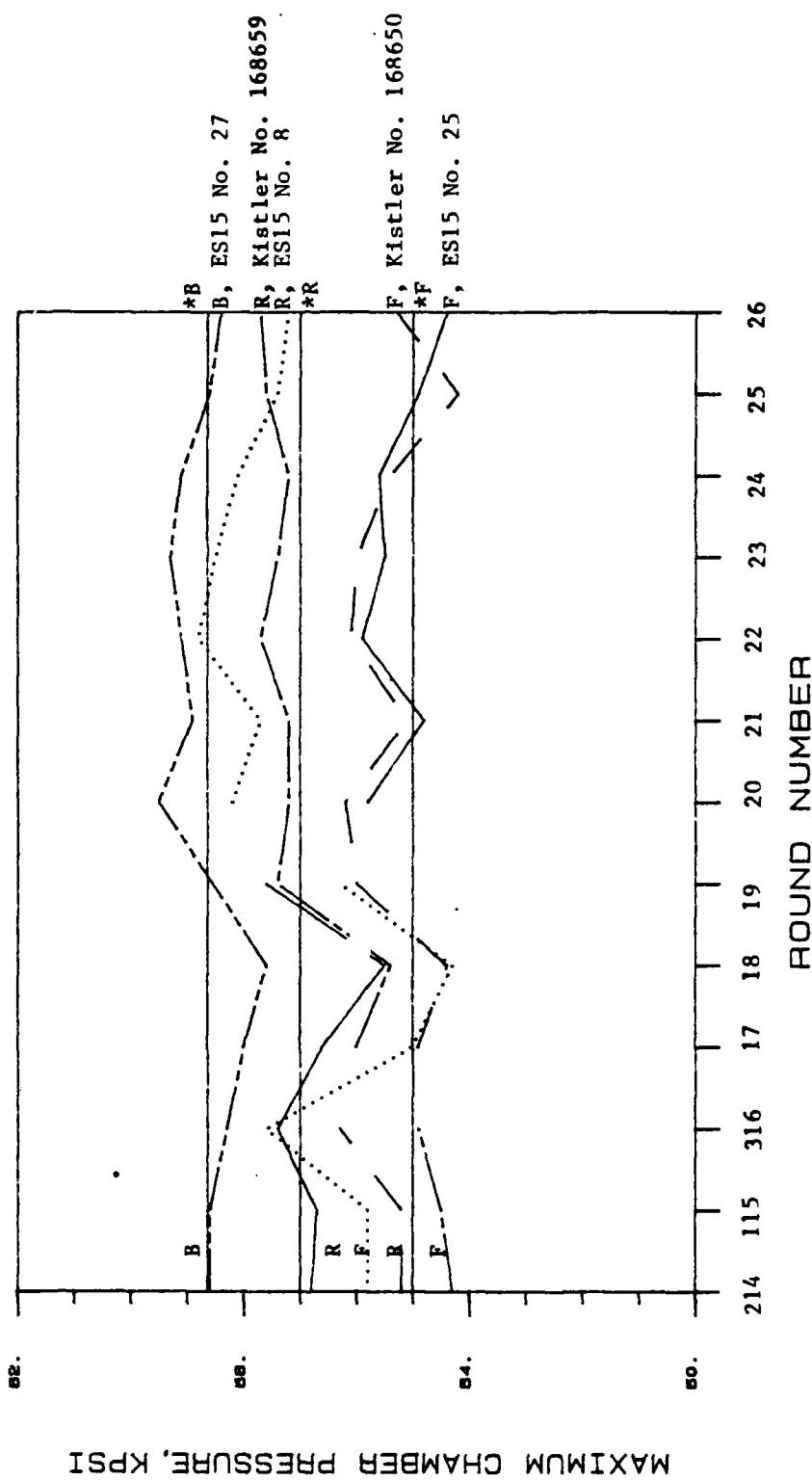


Figure 2.1-7b. Round No. T7.

2.2 (Cont'd)

MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER



F = Forward gage position.  
R = Rear gage position.  
B = Base gage position.  
\* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.2-1(1). Maximum chamber pressure.

## MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER

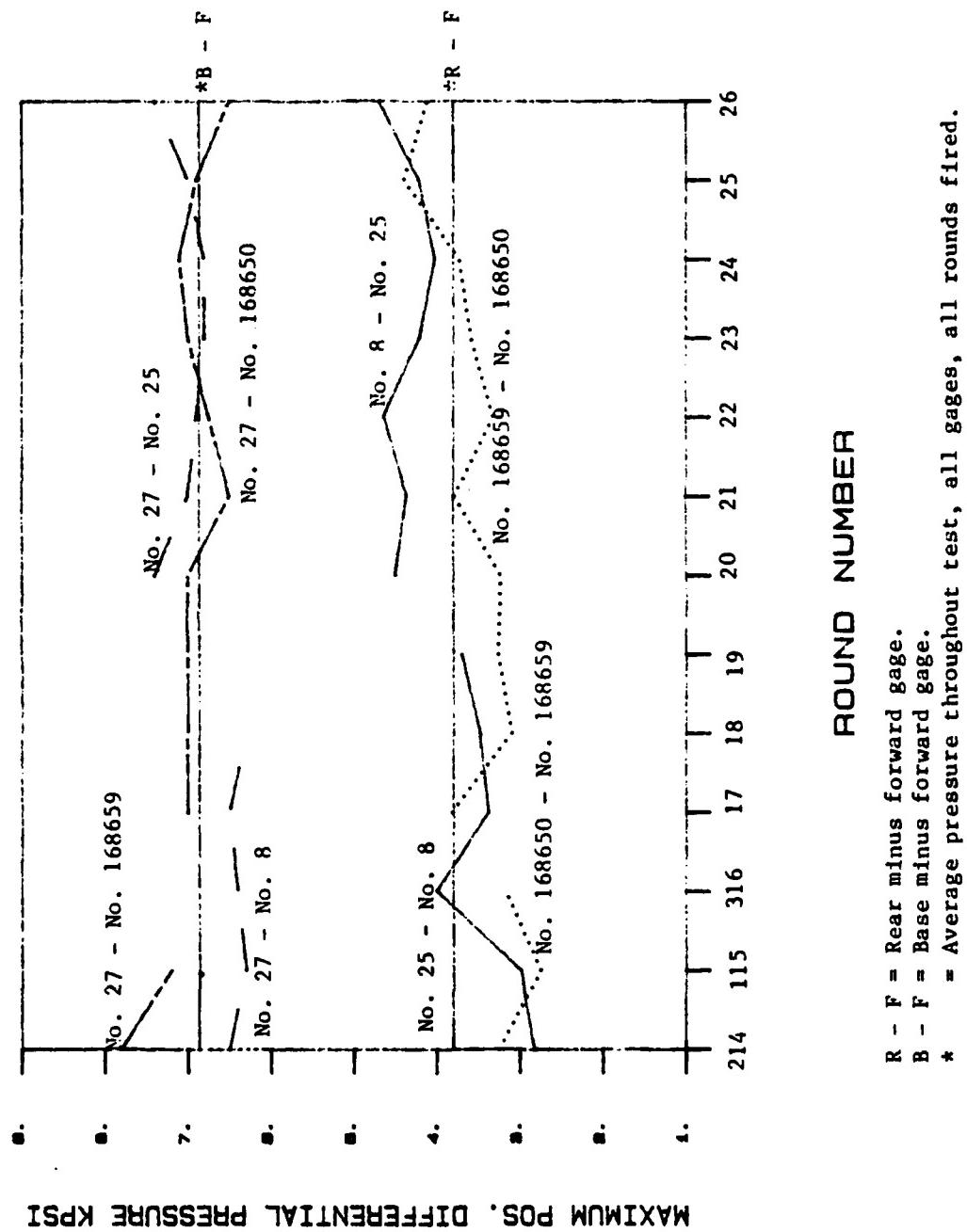


Figure 2.2-1(2). Maximum positive differential pressure.

2.2 (Cont'd)

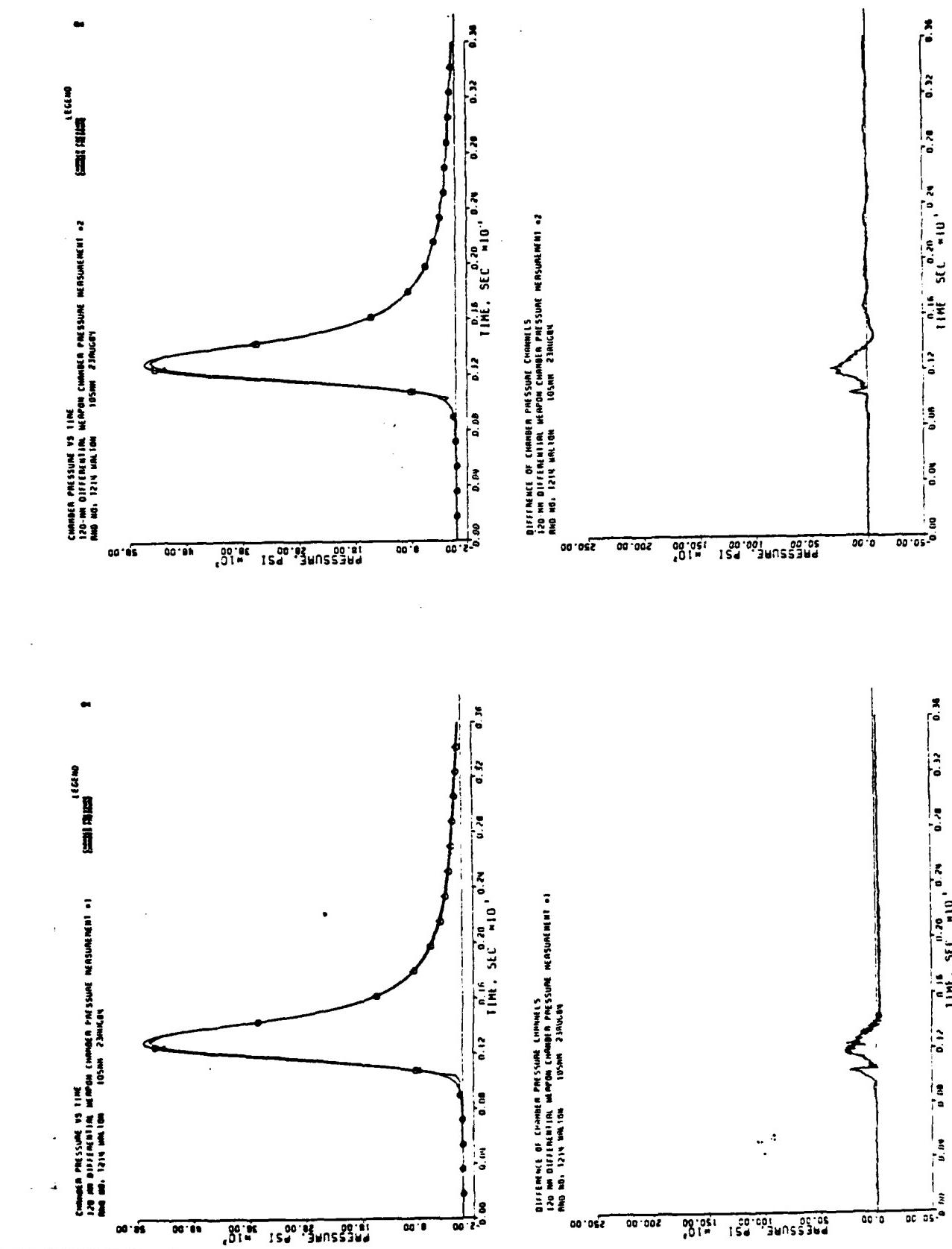


Figure 2.2-1a. Round No. T214.

2.2 (Cont'd)

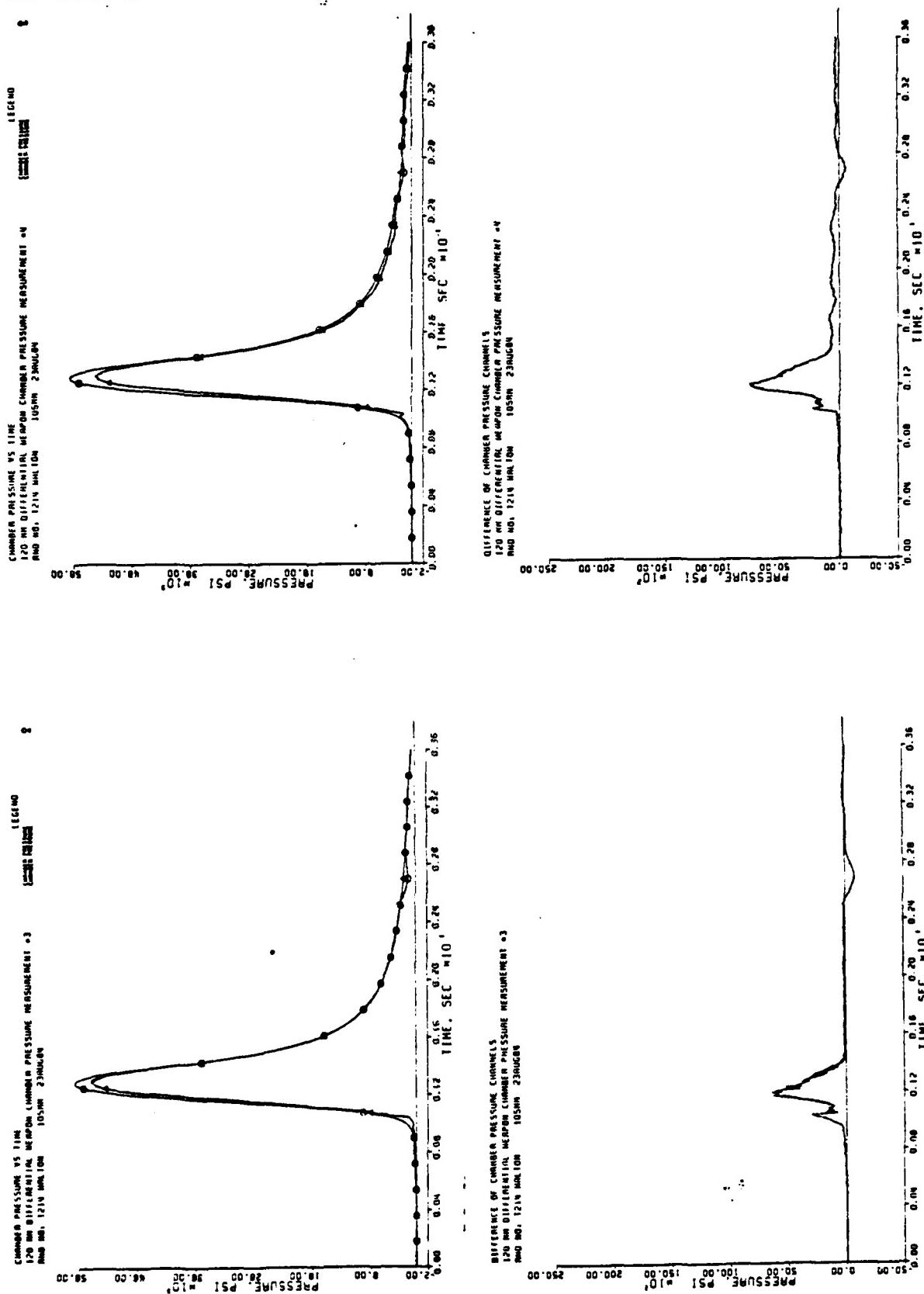


Figure 2.2-1b. Round No. T214.

2.2 (Cont'd)

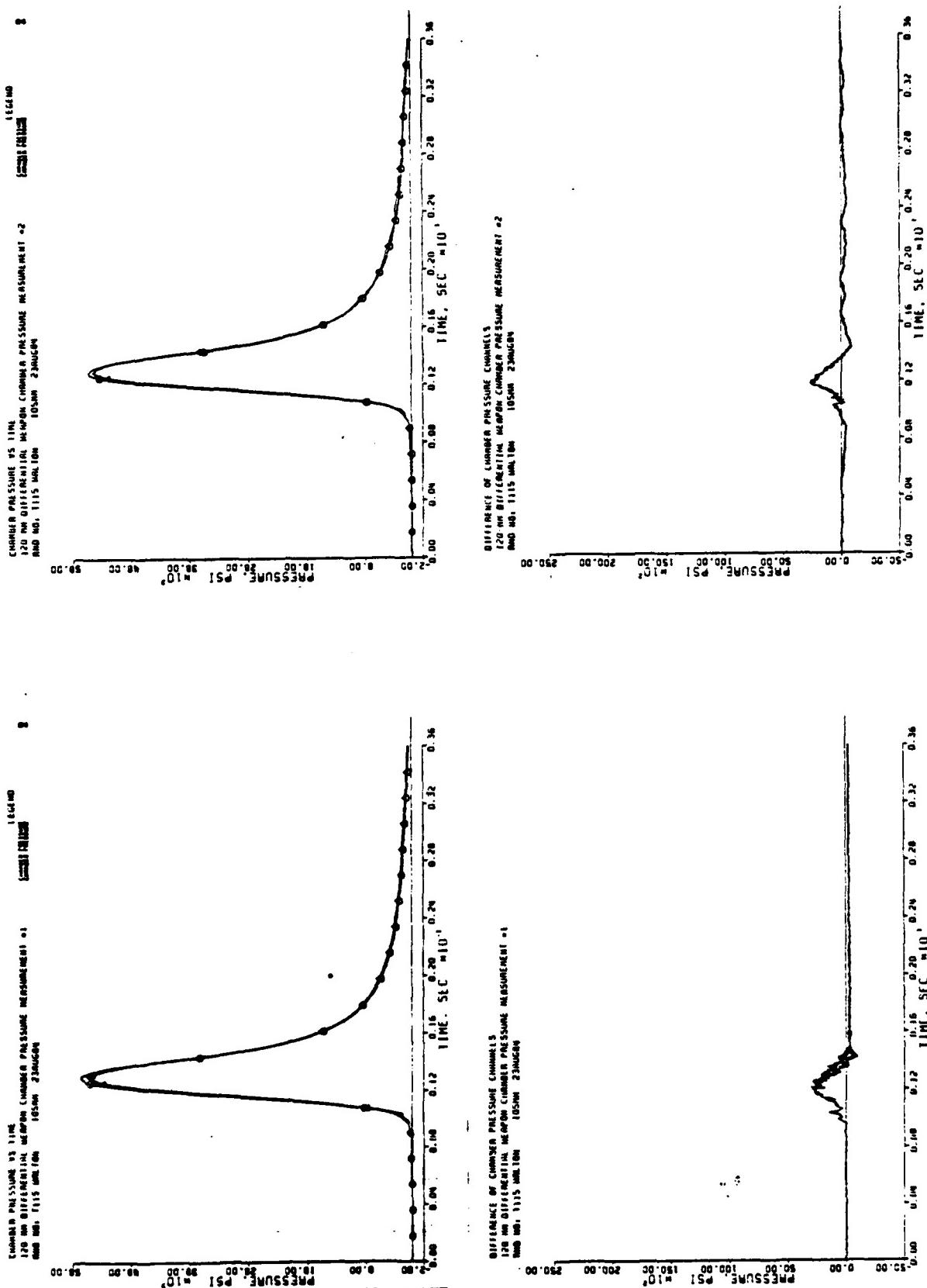


Figure 2.2-2a. Round No. T115.

2.2 (Cont'd)

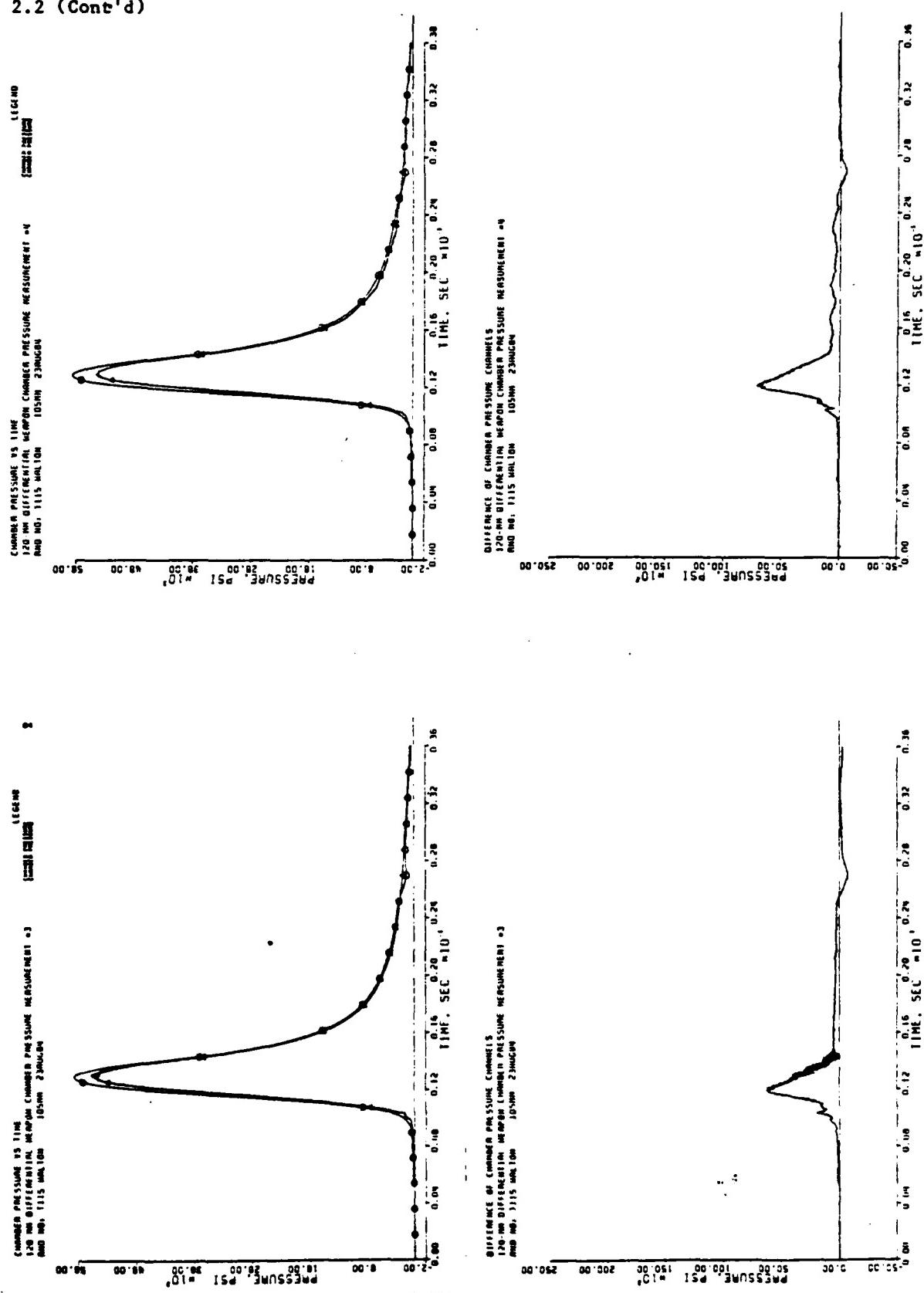


Figure 2.2-2b. Round No. T115.

2.2 (Cont'd)

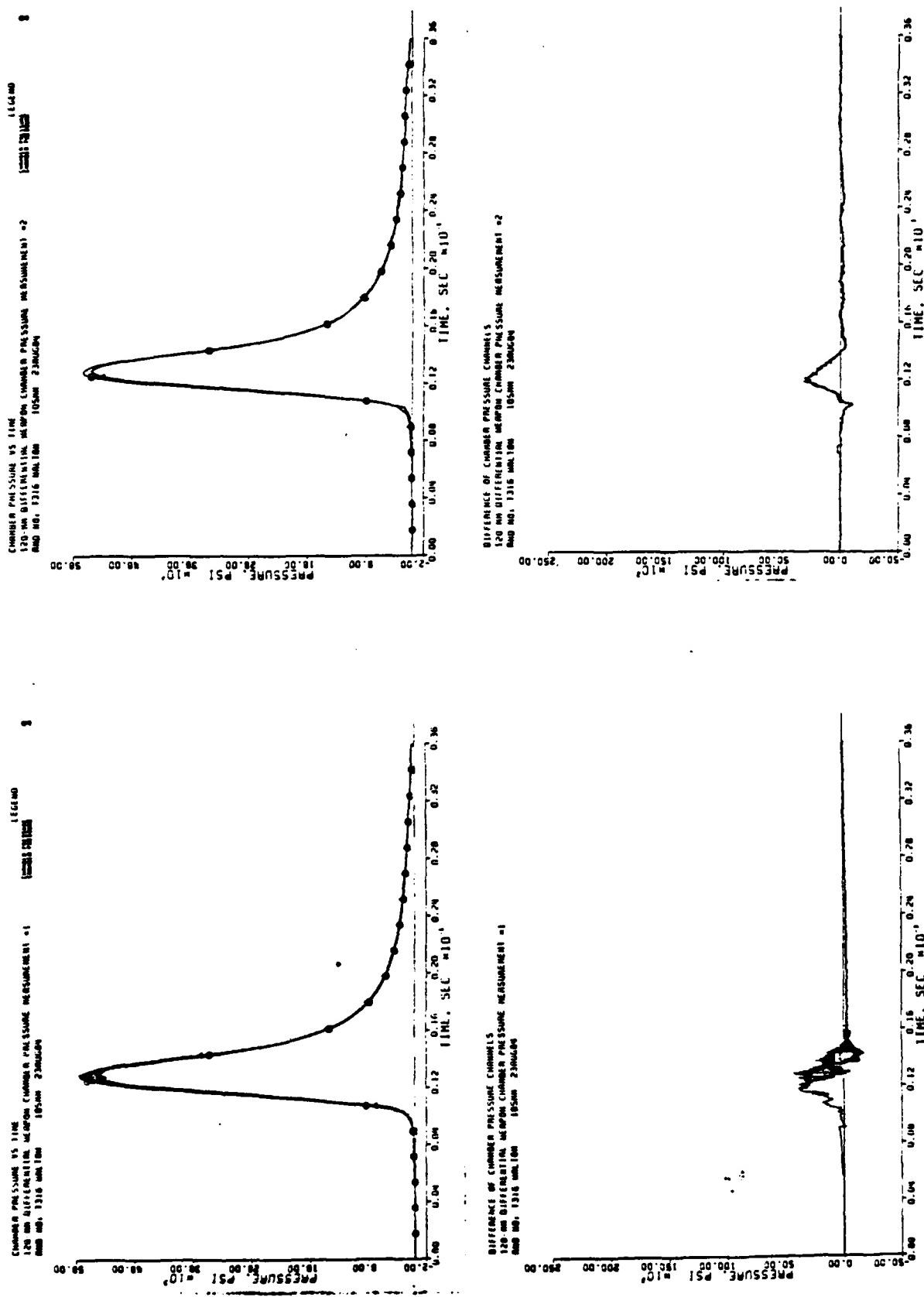


Figure 2.2-3. Round No. T16.

2.2 (Cont'd)

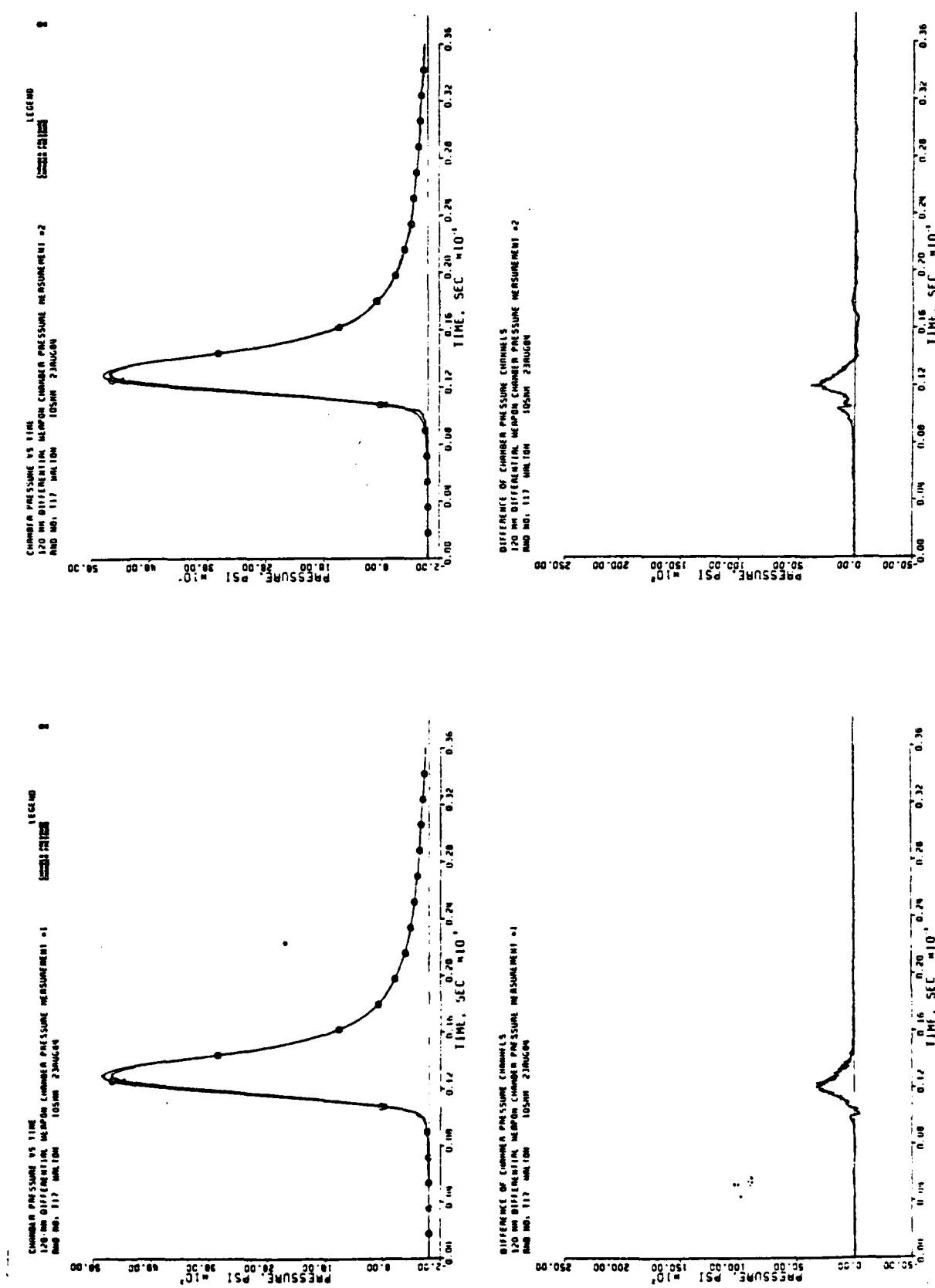


Figure 2.2-4a. Round No. T17.

2.2 (Cont'd)

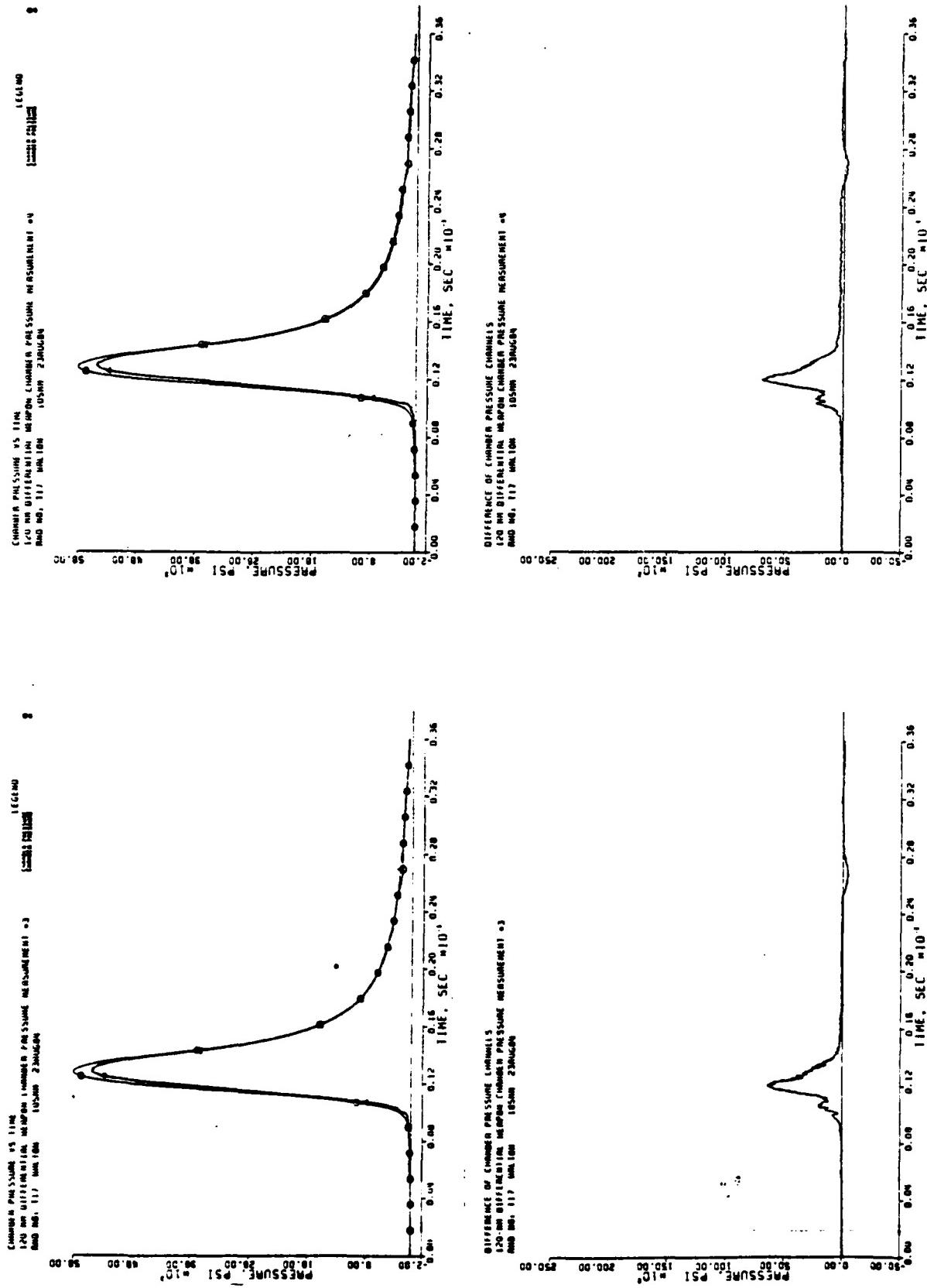


Figure 2.2-4b. Round No. T17.

2.2 (Cont'd)

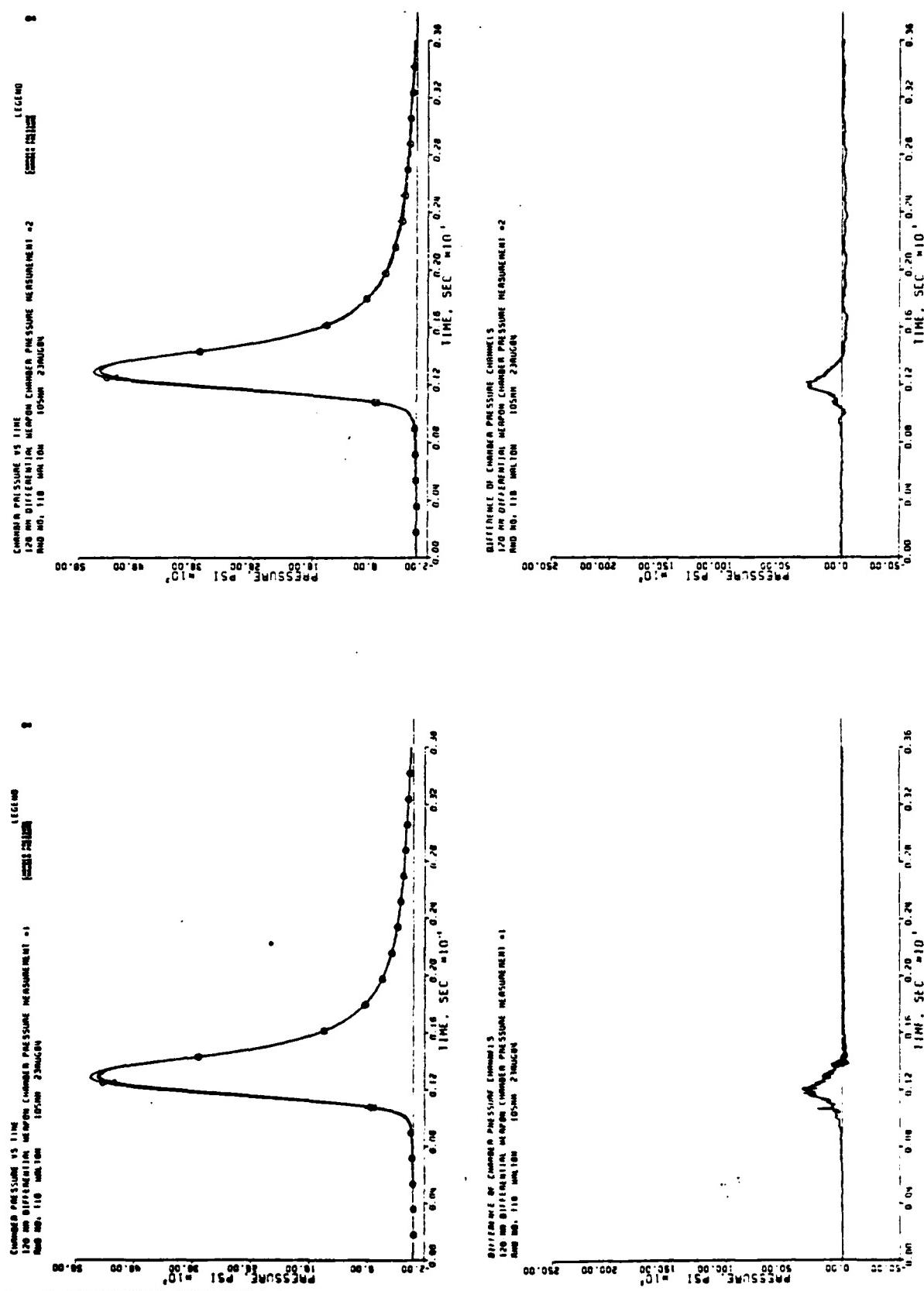


Figure 2.2-5a. Round No. T18.

2.2 (Cont'd)

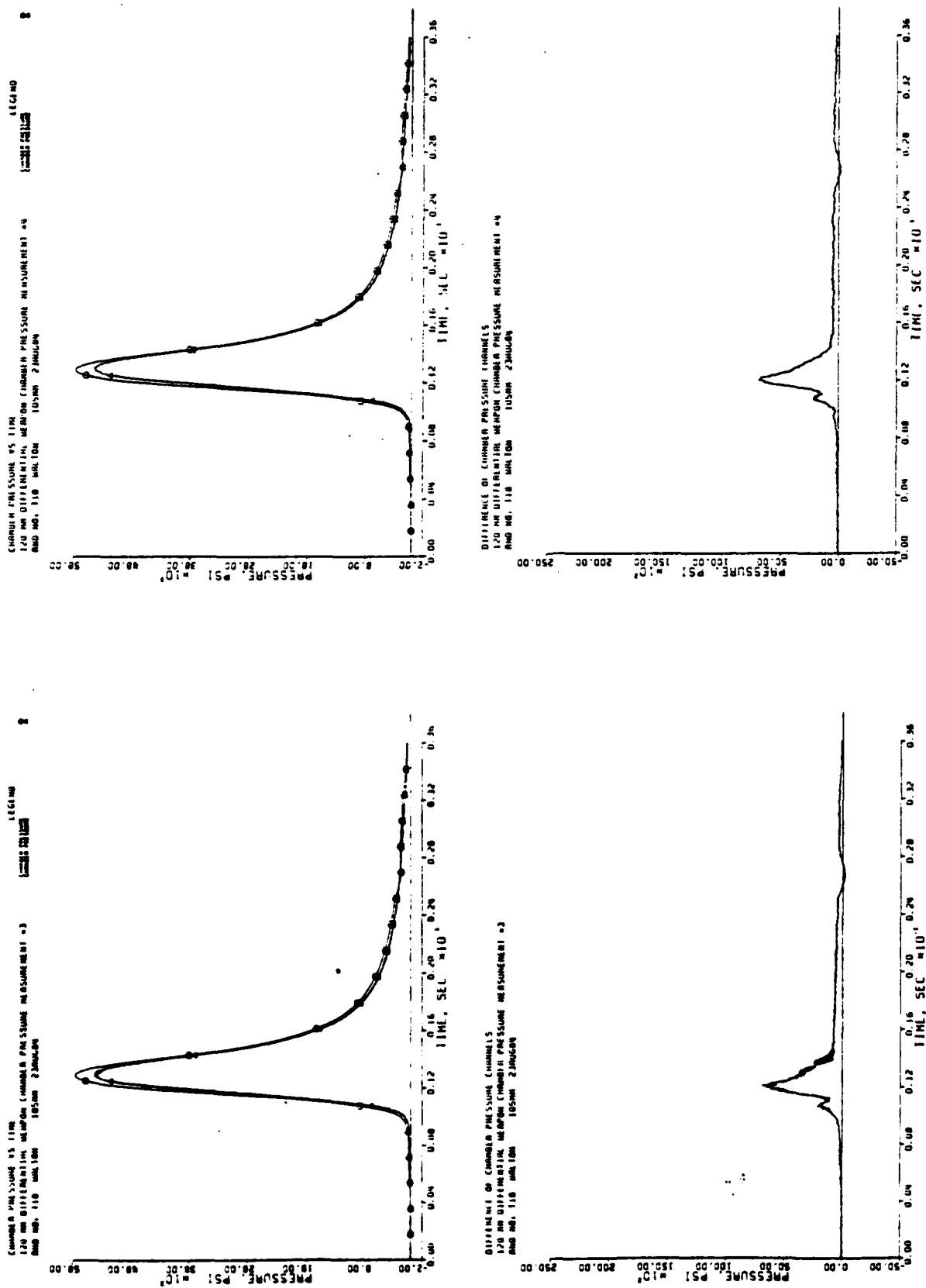


Figure 2.2-5b. — Round No. T18.

## 2.2 (Cont'd)

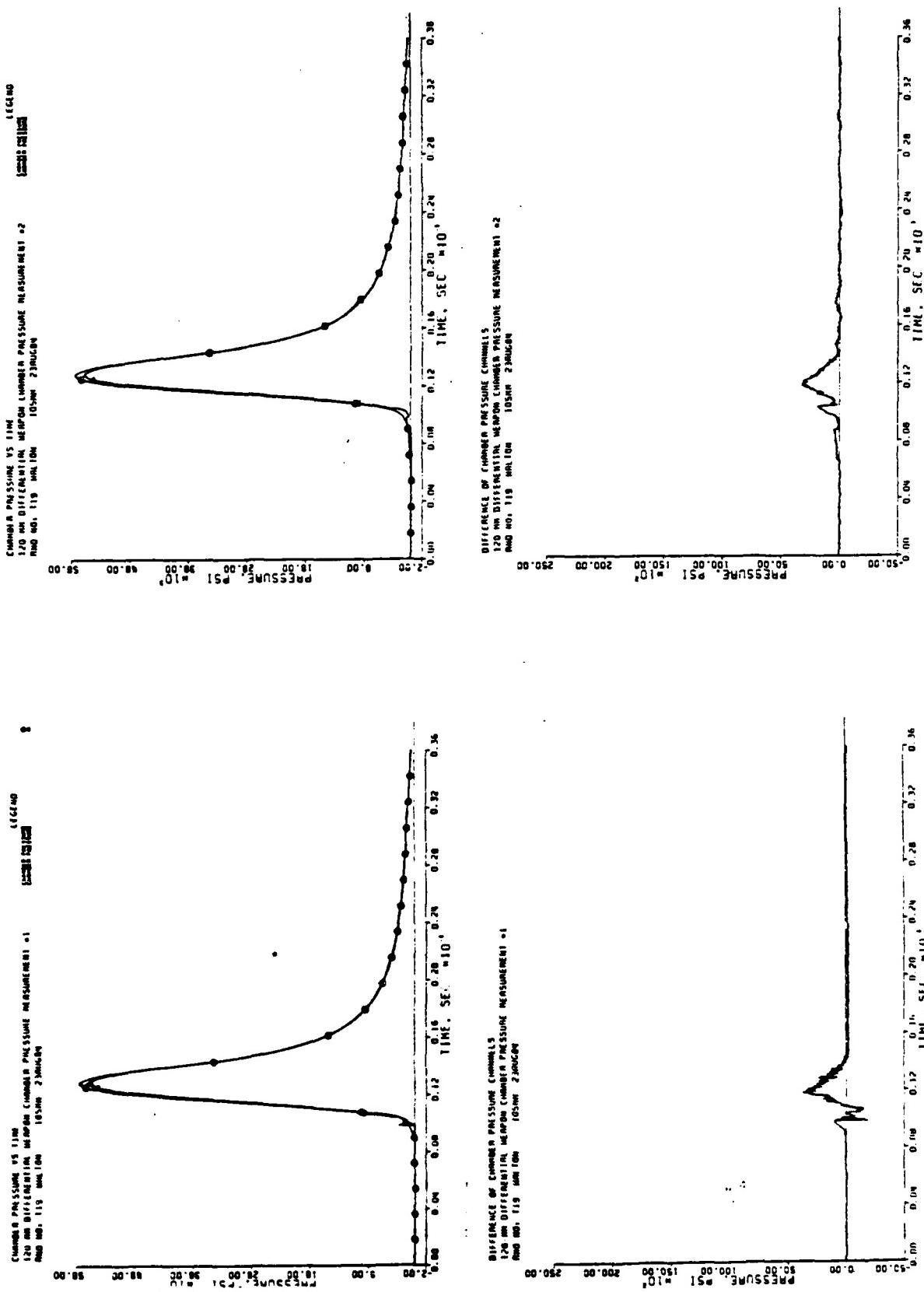
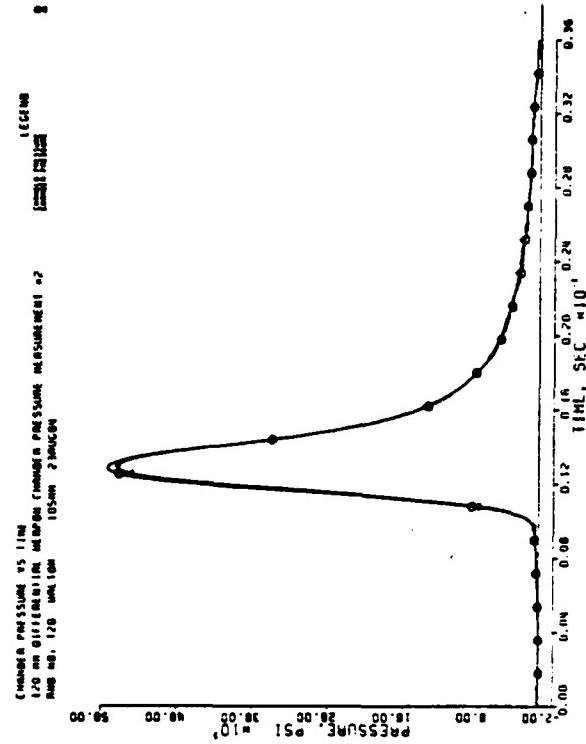
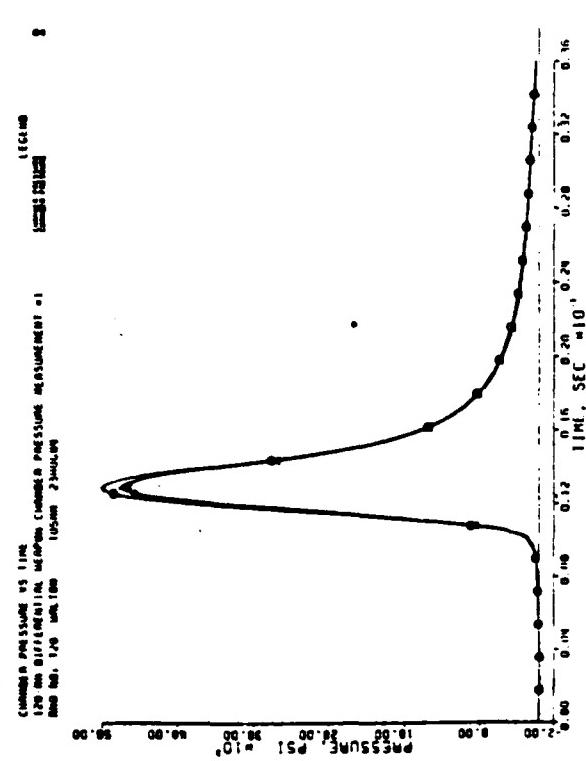


Figure 2.2-6. Round No. 119.

## 2.2 (Cont'd)



DIFERIMENT OF CHAMBER PRESSURE CHANNEL 15  
120 MM DIFFERENTIAL WEAPON CHAMBER PRESSURE MEASUREMENT #2  
RNU NO. 120 MILION 105MM 2 SHULKA

0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36

Figure 2.2-7a: Round No. T20.

2.2 (Cont'd)

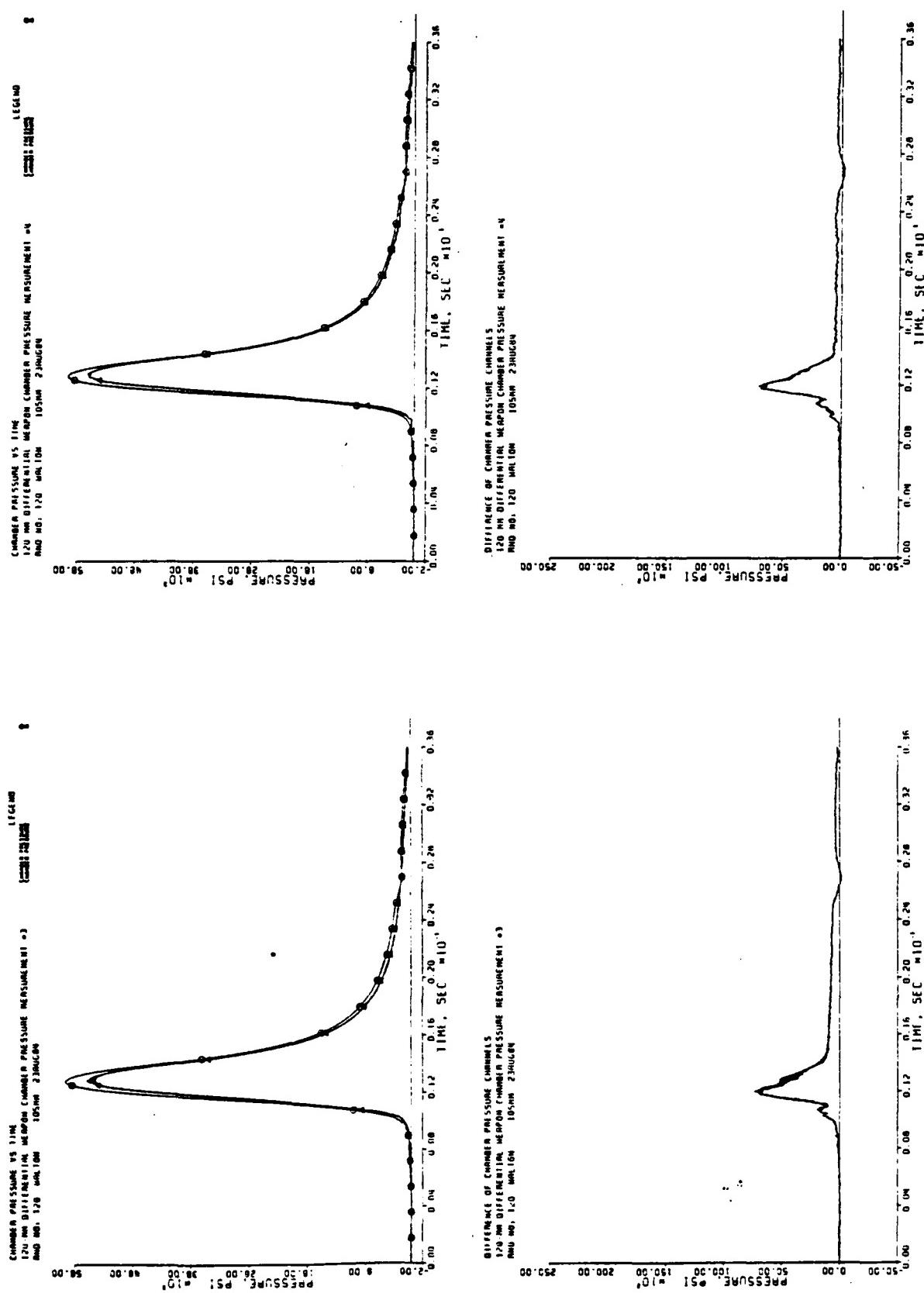
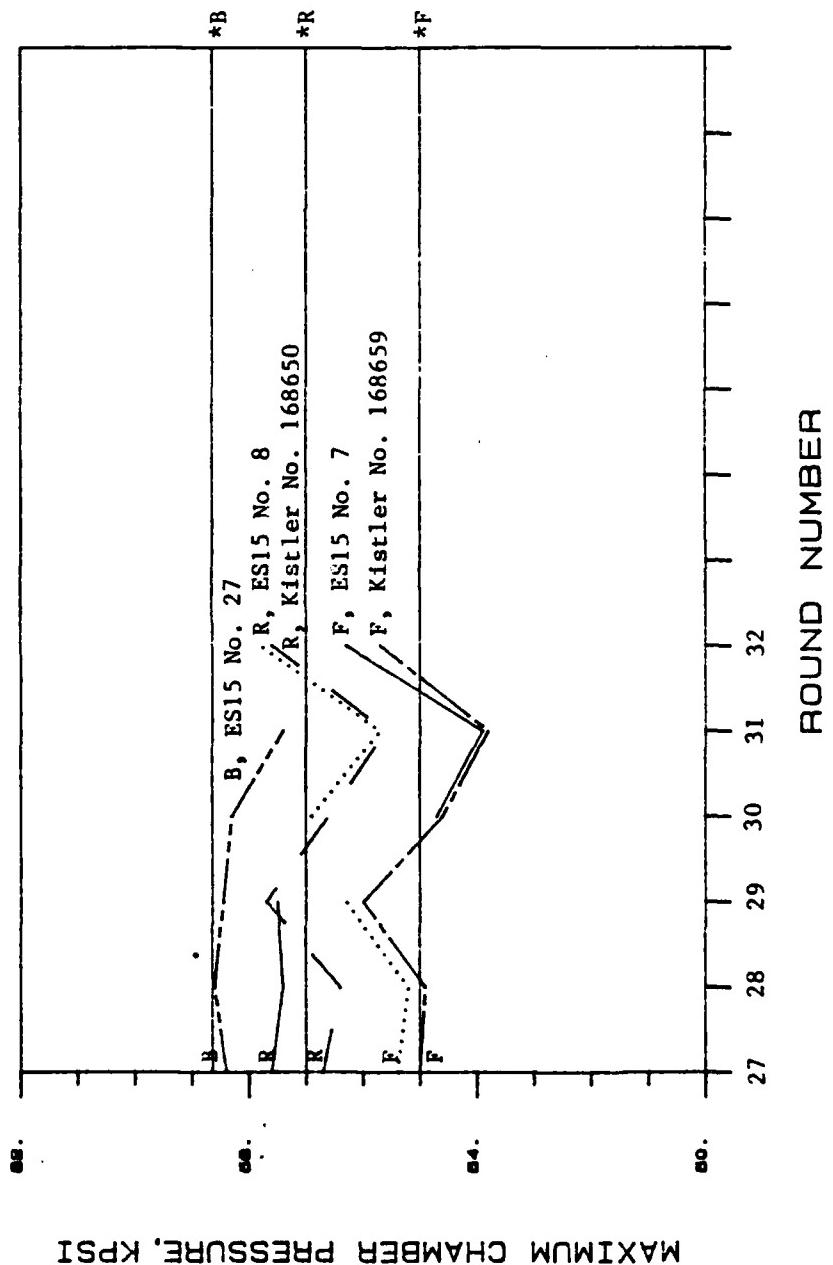


Figure 2.2-7b. Round No. T20.

2.3 (Cont'd)

MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER



F = Forward gage position.  
 R = Rear gage position.  
 B = Base gage position.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.3-1(1). Maximum chamber pressure.

## 2.3 (Cont'd)

TABLE 2.3-1. CHAMBER PRESSURE DATA - PHASE Ic

105-mm Tank Gun  
 Tube SN 25970  
 Cartridge: M392A2  
 Temperature: +70° F  
 Date Fired: 27 August 1984

Rd No.	Ch 1	AMP Position	Ch 2	AMP Position	Ch 3	AMP Position	Ch 4	AMP Position	Ch 5	Maximum Chamber Pressure, kpsi			Maximum Initial +AP, psi						
										ES15 No. 7 in Adapter No. 1			ES15 No. 8 in Adapter No. 2						
										Gage	Gage	Gage	Position	Position	Position				
T27	57.6	316	Rear	55.4	316	Forward	56.7	316	Rear	55.0	316	Forward	56.4	316	Base	3900	3600	6600	6900
T28	57.4	316	Rear	55.2	316	Forward	56.4	316	Rear	54.9	316	Forward	58.6	316	Base	4140	3280	7100	7000
T29	57.9	316	Rear	56.3	316	Forward	57.7	316	Rear	56.0	316	Forward	NR	316	-	4360	3440	MA	NA
T30	54.7	316	Forward	56.9	316	Rear	56.6	316	Rear	54.6	316	Forward	58.3	316	Base	4460	6500	6700	7000
T31	53.9	316	Forward	55.7	316	Rear	55.6	316	Rear	53.8	316	Forward	57.4	316	Base	3740	3640	MA	NA
T32	56.3	316	Forward	57.8	316	Rear	57.6	316	Rear	55.7	316	Forward	NR	316	-	4530	3670	MA	NA

NA = Not applicable.

NR = Not recorded.

Ch = Channel.

### 2.3 PHASE Ic. ROUNDS 27 THROUGH 32, TUBE 25970

Yuma ES15 gage No. 7 with adapter No. 1 was mounted in the rear gage position, and ES15 gage No. 8 with adapter No. 2 was mounted in the forward position on the right side. Kistler gage No. 168650 was mounted in the rear position, and No. 168659 was mounted in the forward position throughout Phase Ic. These are the same Kistler gages used during the previous phase.

The differential records produced by the ES15 gages show a significant amount of noise, resulting primarily from the forward gage position. Round 27 has a slight crossover of forward and rear gage pressures and a significant positive offset occurs on round 31. Other than these rounds, the differential records return to zero in an acceptable manner. The differential peak pressures produced by the ES15 gages are higher than those produced by the Kistler gages, before and after ES15 gage positions were changed after round 29. However, the shapes of the differential waveforms produced by each set of gages are in agreement, and the maximum peak differential difference is 1020 psi. Compared to the ES15 gage differential peak of 4460 psi, this 23% difference is well within the performance expected of a differential measurement.

The Kistler 6211 gages were not changed in any respect during this phase. The differential plots display minimal noise and zero offset.

The base - forward gage differential peaks are in excellent agreement, differing by less than 300 psi, or 4% when compared to the higher reading. This is a significant result, considering the differences in zero baseline offset between the records.

2.2 (Cont'd)

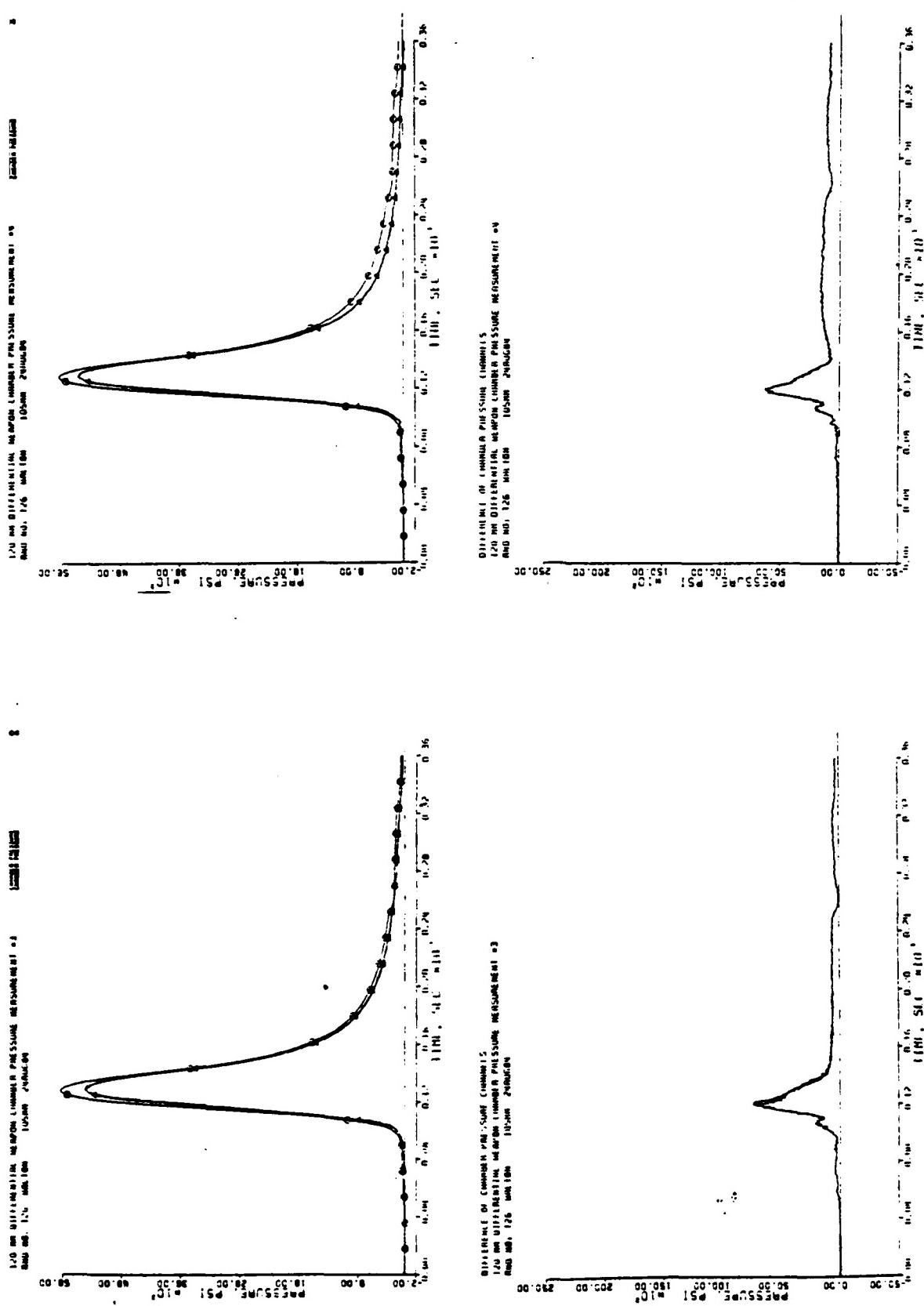


Figure 2.2-13b. Round No. T26.

2.2 (Cont'd)

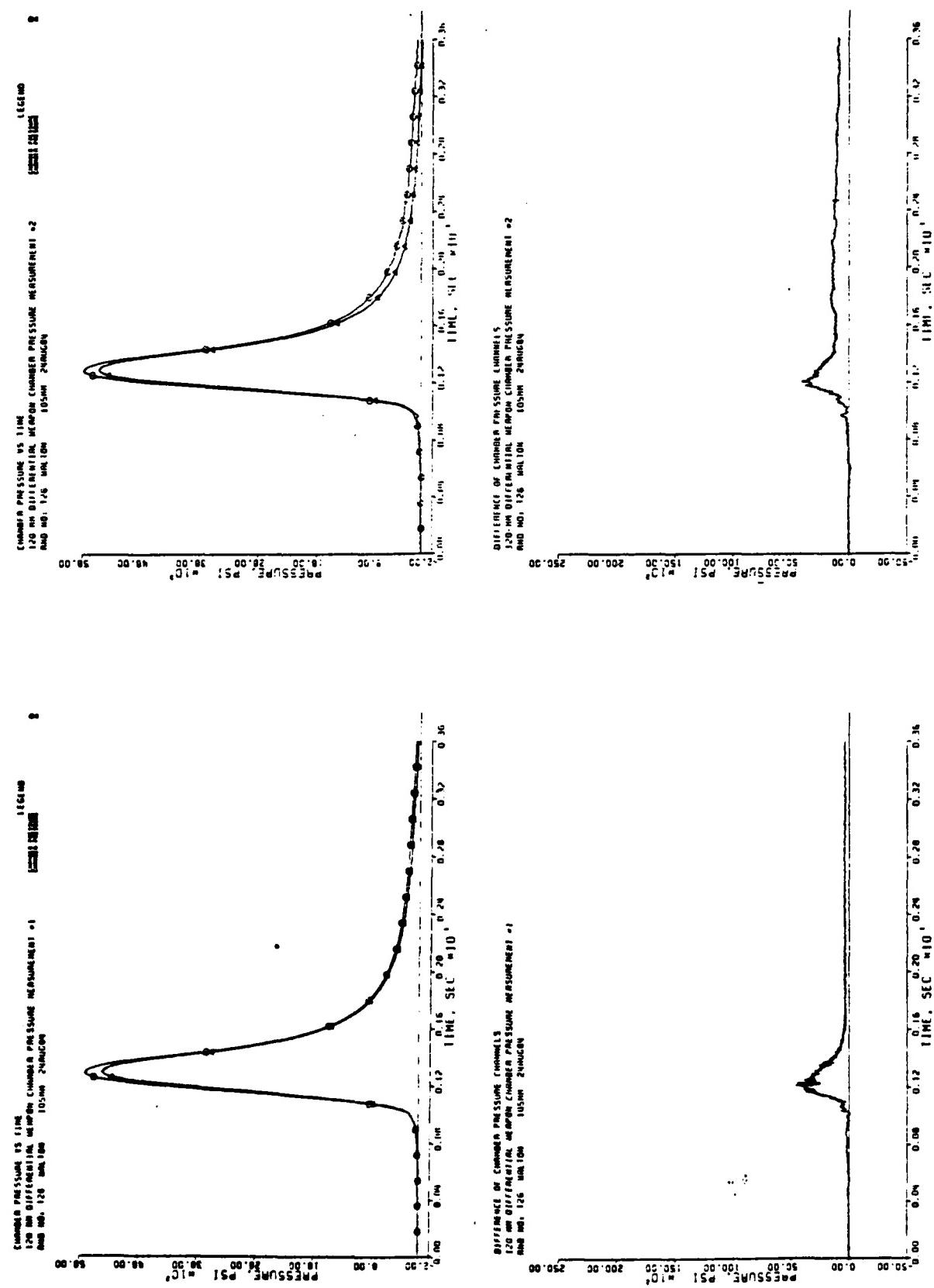


Figure 2.2-13a. - Round No. T26.

2.2 (Cont'd)

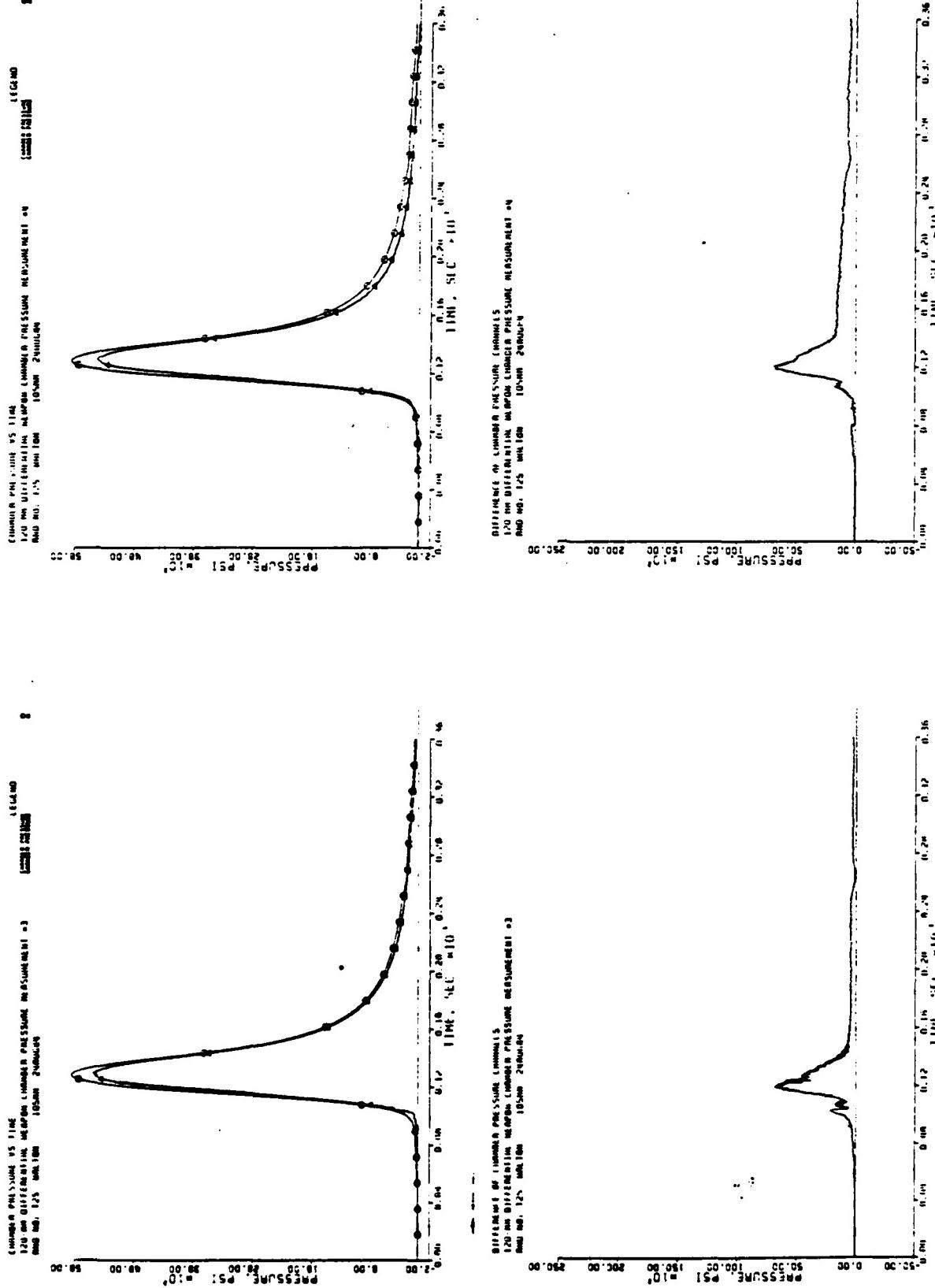


Figure 2.2-12b. Round No. T25.

2.2 (Cont'd)

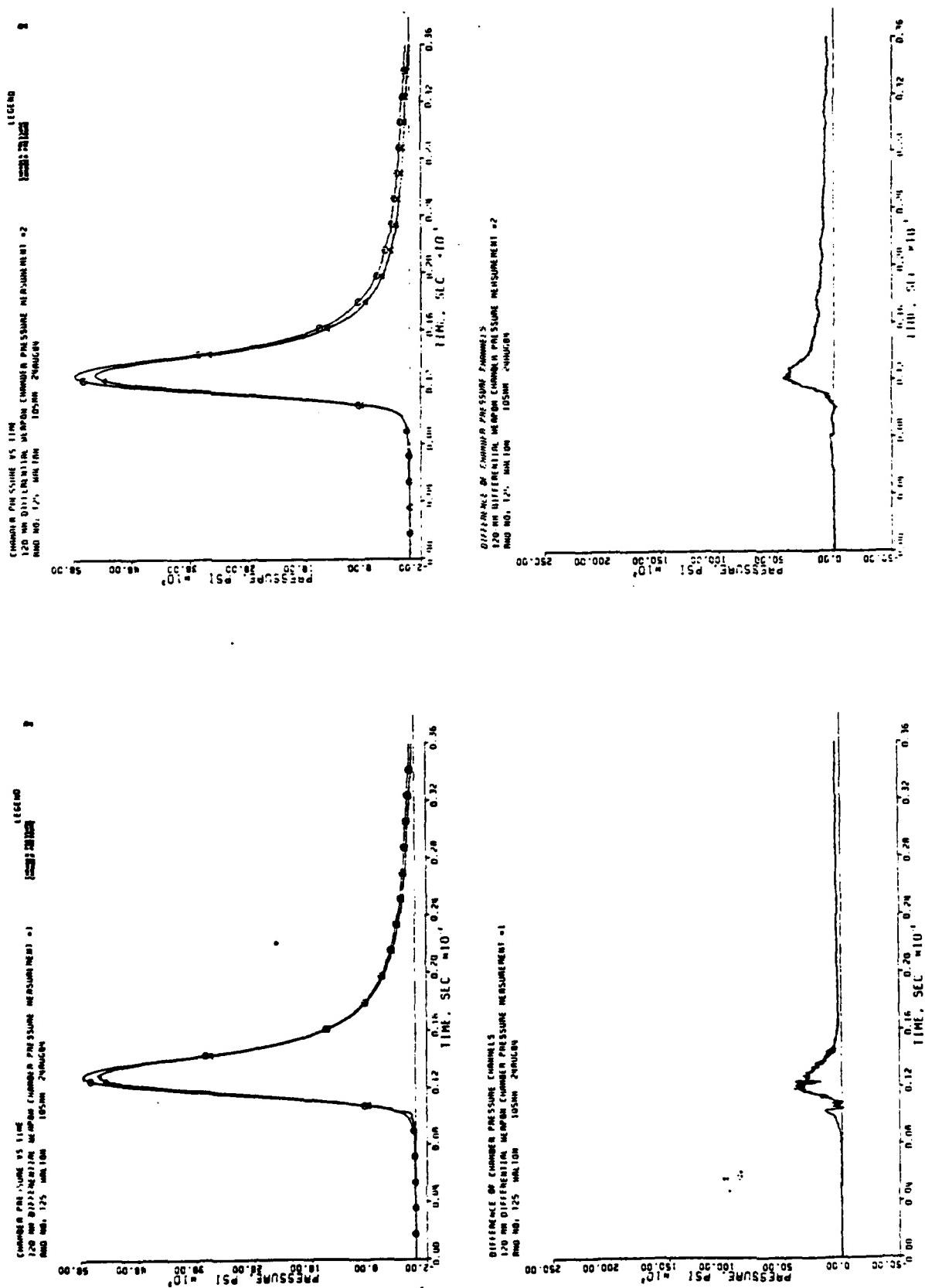


Figure 2.2-12a. Round No. 125.

## 2.2 (Cont'd)

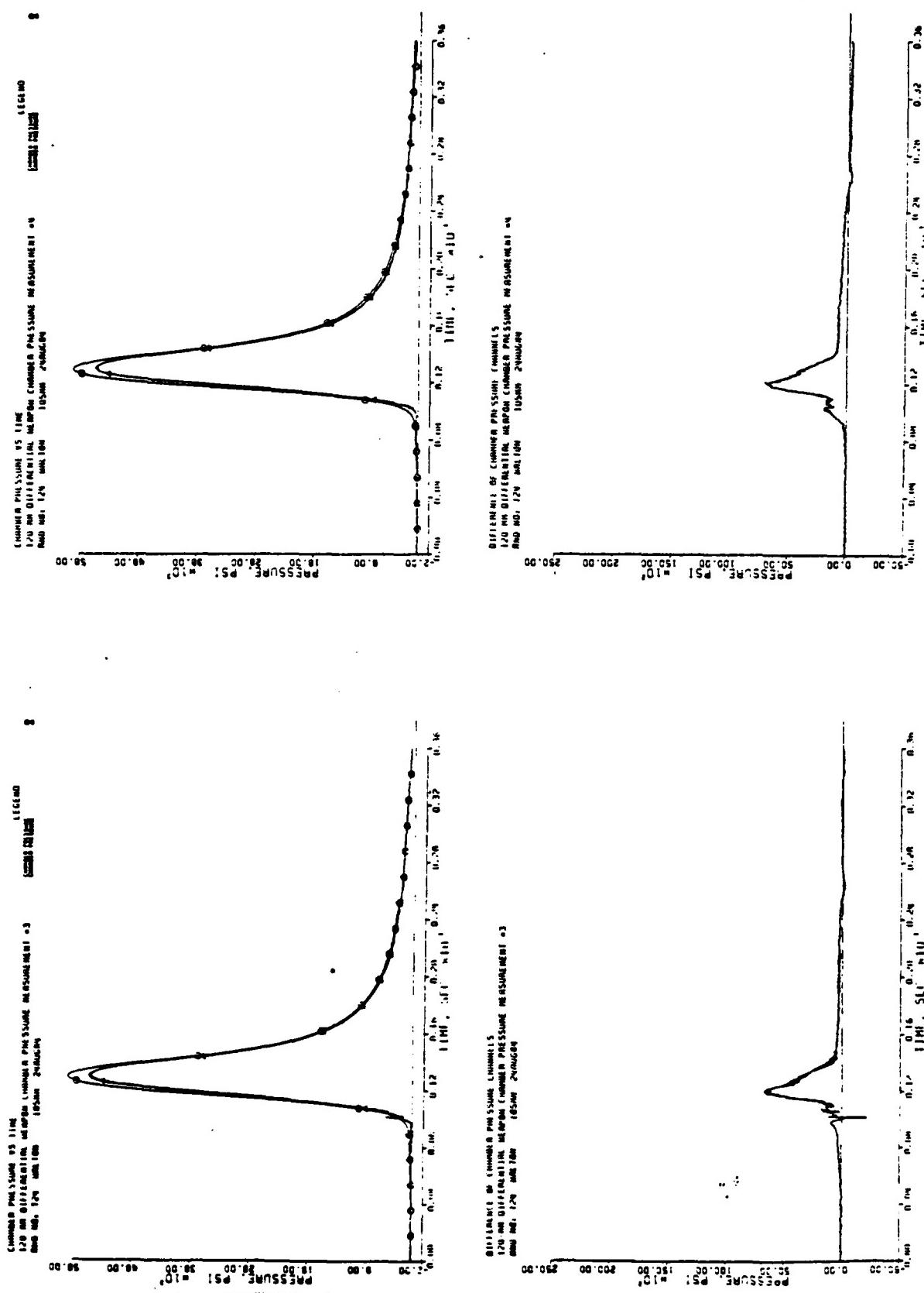


Figure 2.2-11b. Round No. T24.

2.2 (Cont'd)

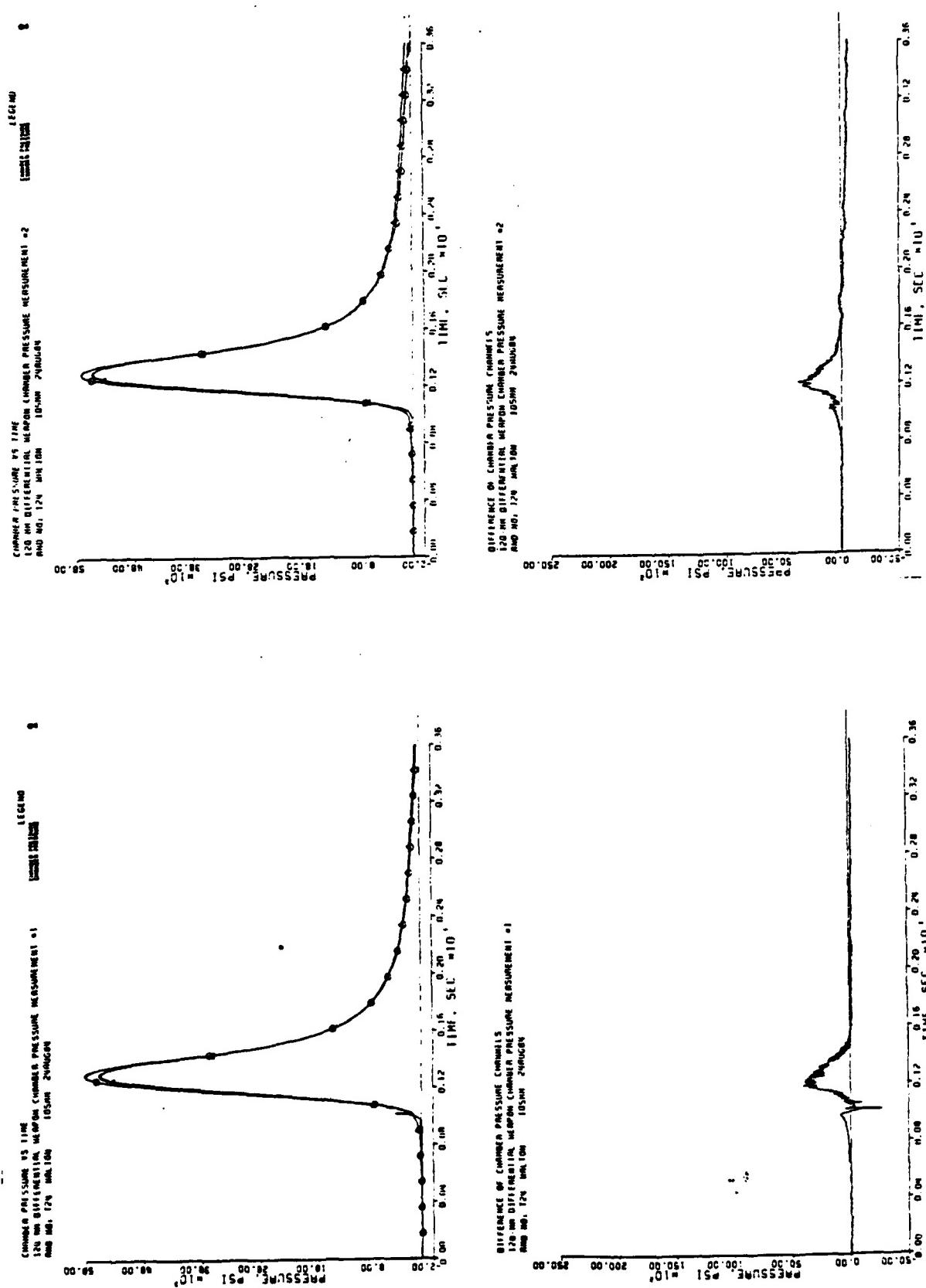


Figure 2.2-11a. Round No. T24.

2.2 (Cont'd)

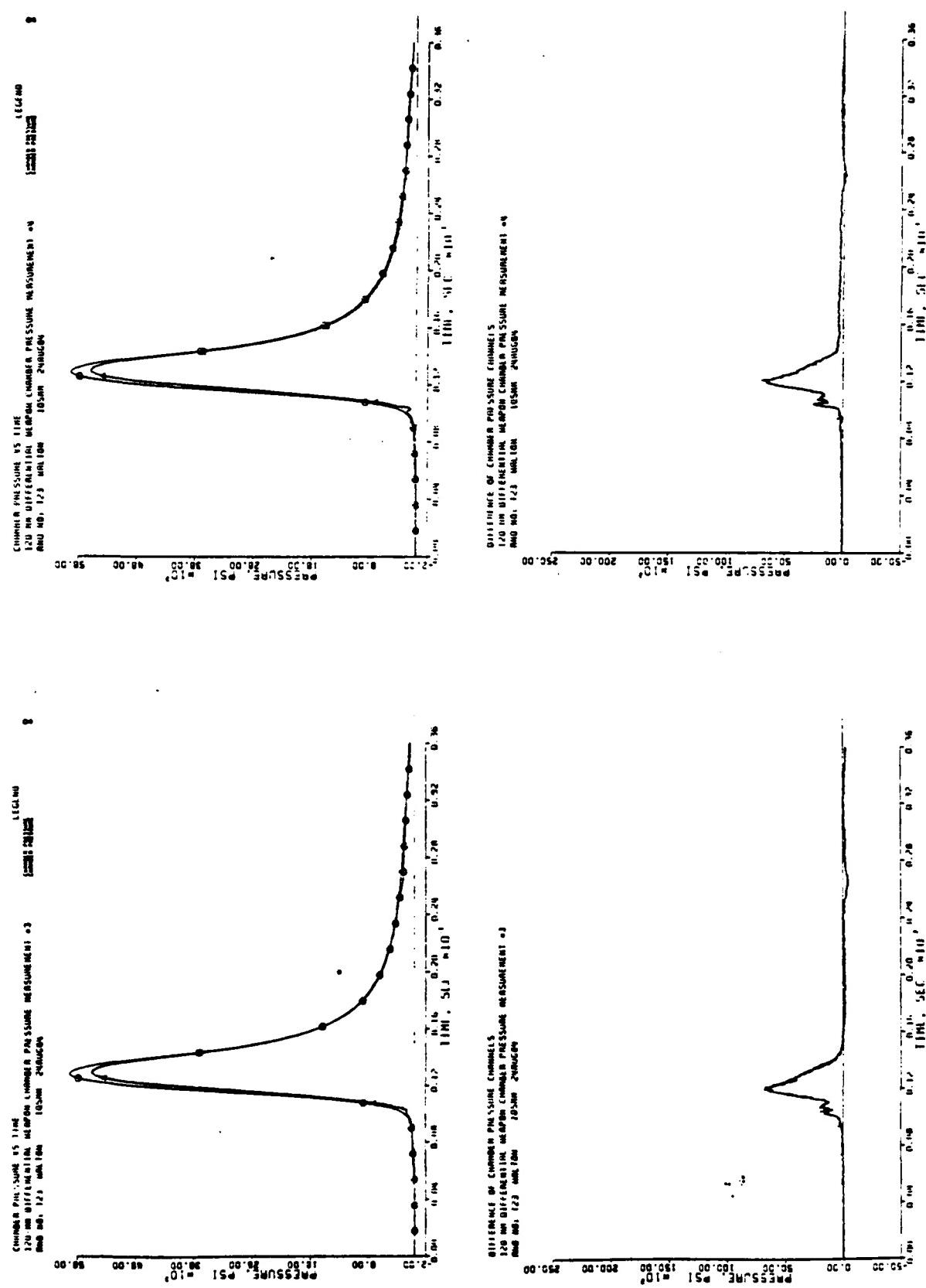


Figure 2.2-10b. Round No. T23.

2.2 (Cont'd)

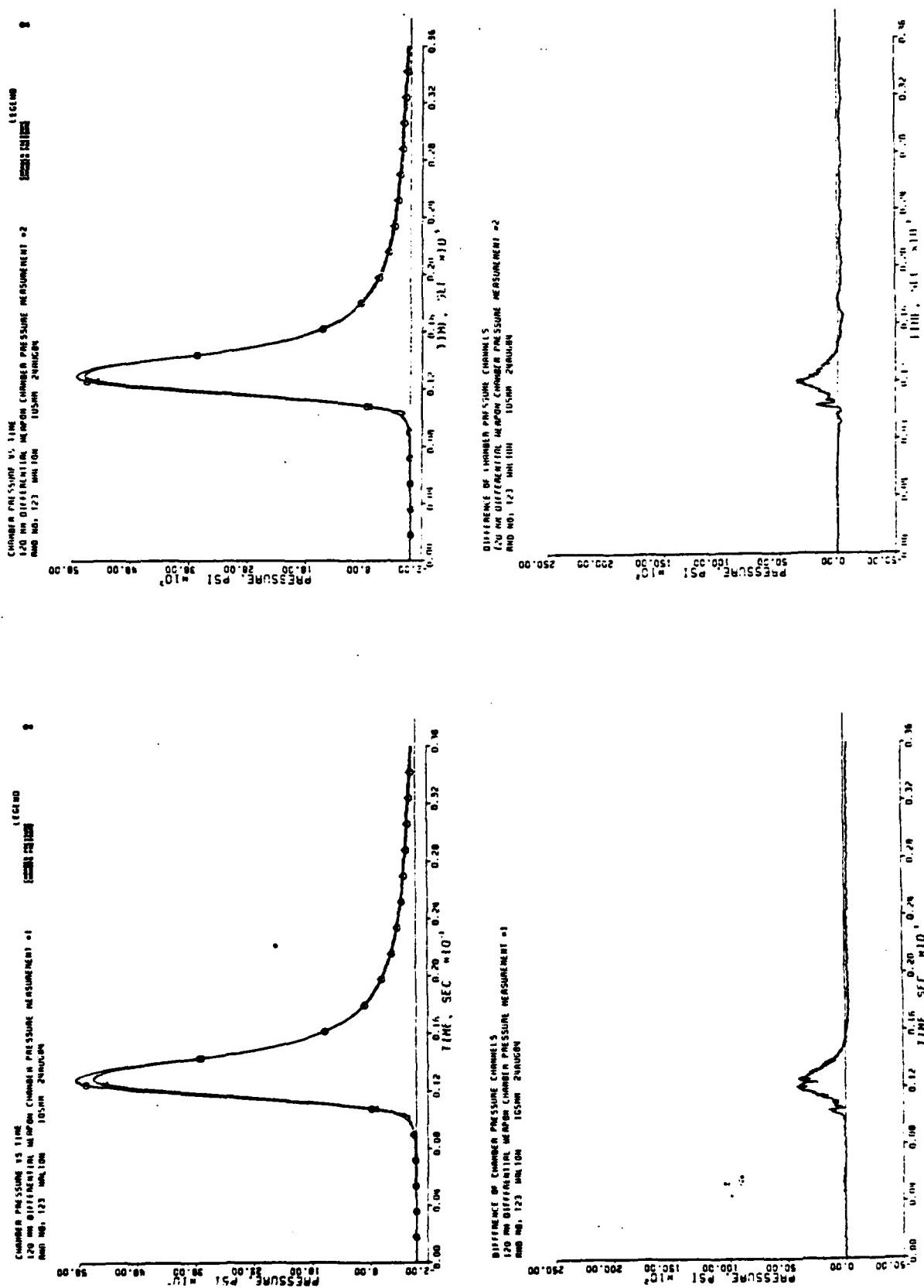


Figure 2.2-10a. Round No. T23.

2.2 (Cont'd)

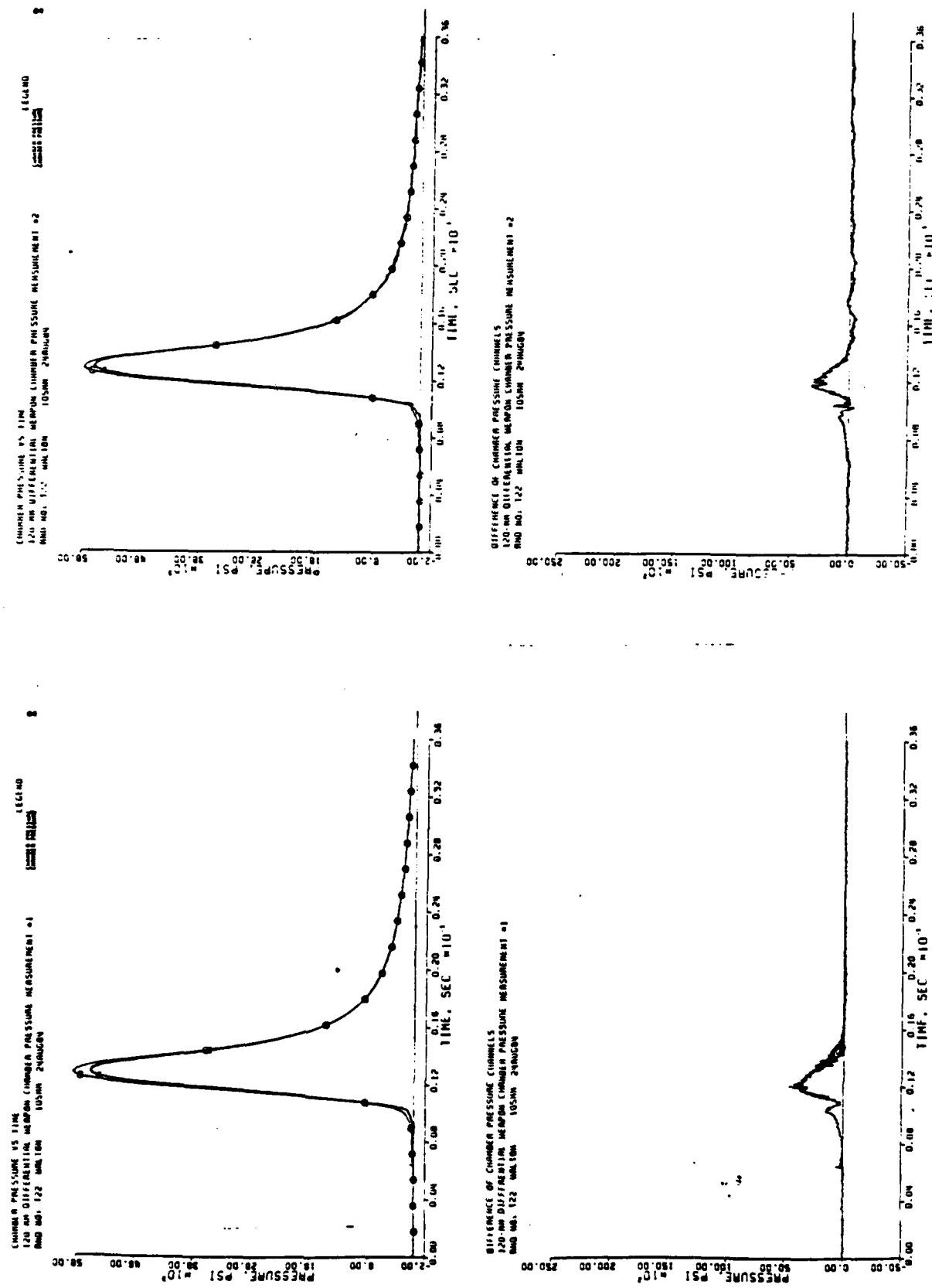


Figure 2.2-9. Round No. T22.

2.2 (Cont'd)

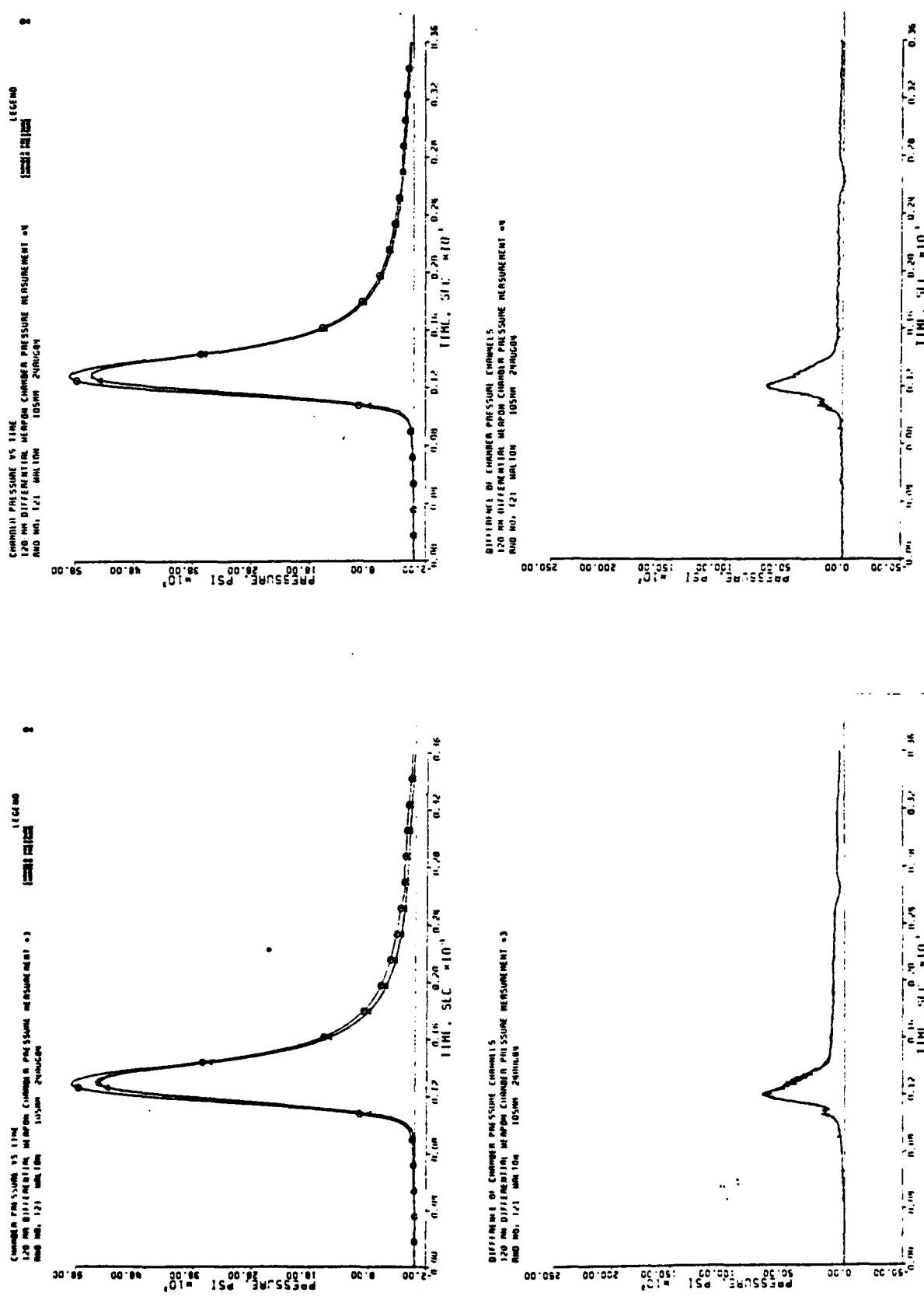
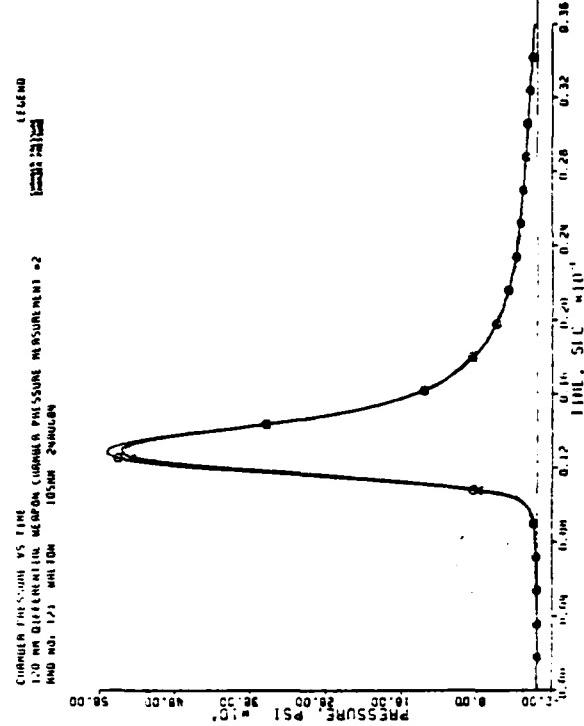
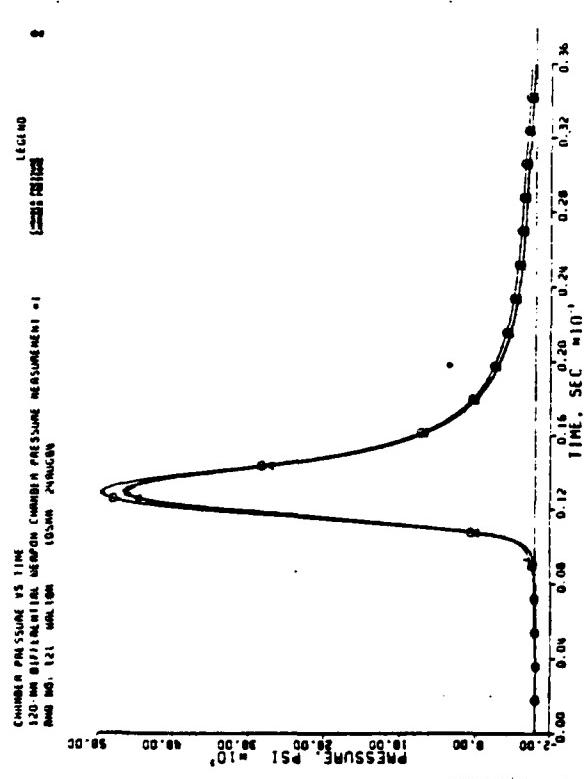


Figure 2.2-8b. Round No. T21.

## 2.2 (Cont'd)



**DIFFERENCE OF CHARGE PRESSURE CHANNELS  
120-MM DISSEMENAL WEAPON CHARGE PRESSURE MEASUREMENTS**

DISTRIBUTION OF CHANNEL PHYSICAL CHANNELS  
120 NM DISTANCE WITH MEAN CHANNEL PASSURE MEASUREMENTS

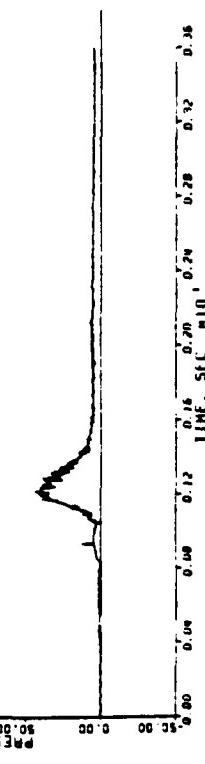
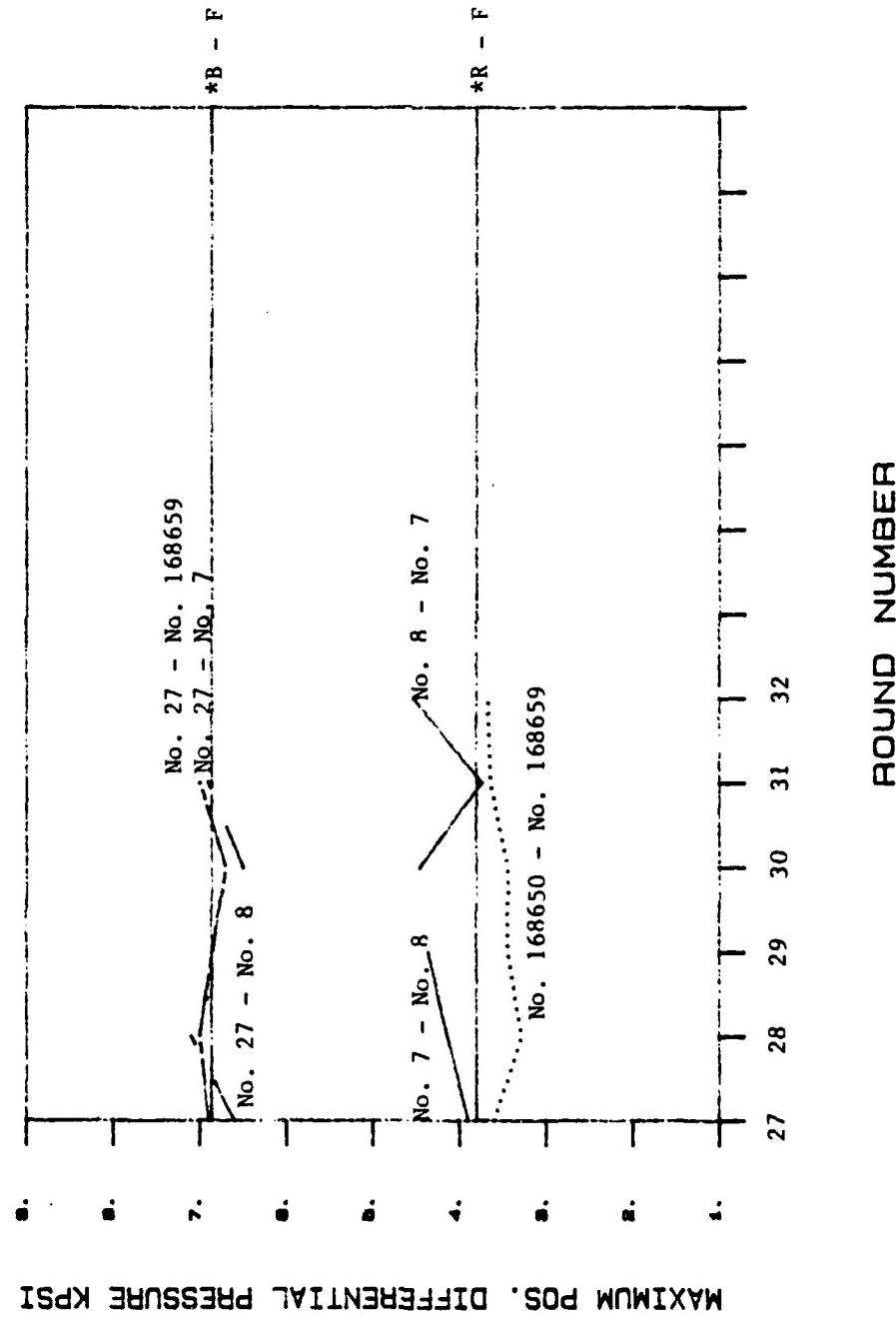


Figure 2.2-8a. -- Round No. T21.

## MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.  
 B - F = Base minus forward gage.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.3-1(2). Maximum positive differential pressure.

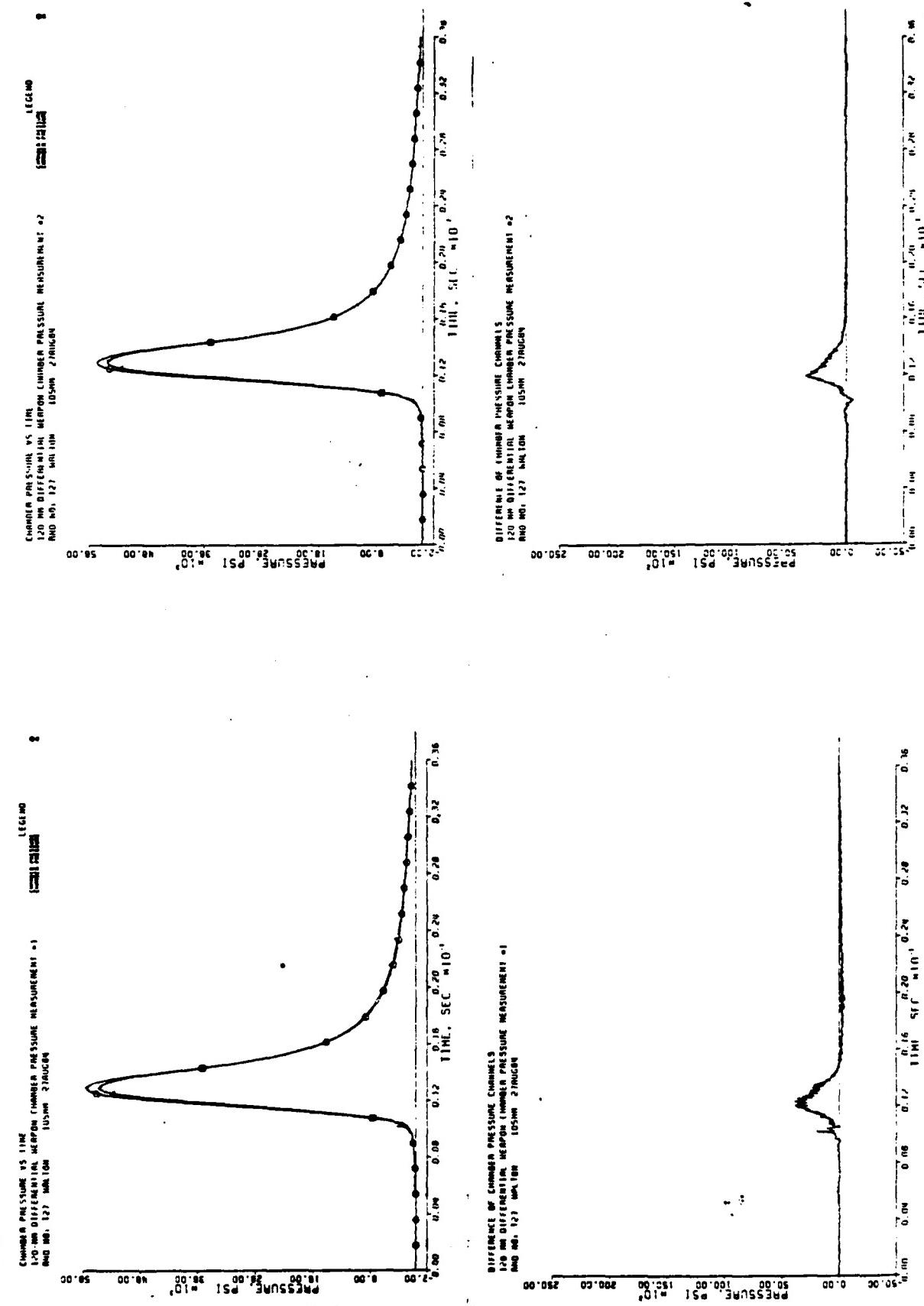


Figure 2.3-1a. Round No. T27.

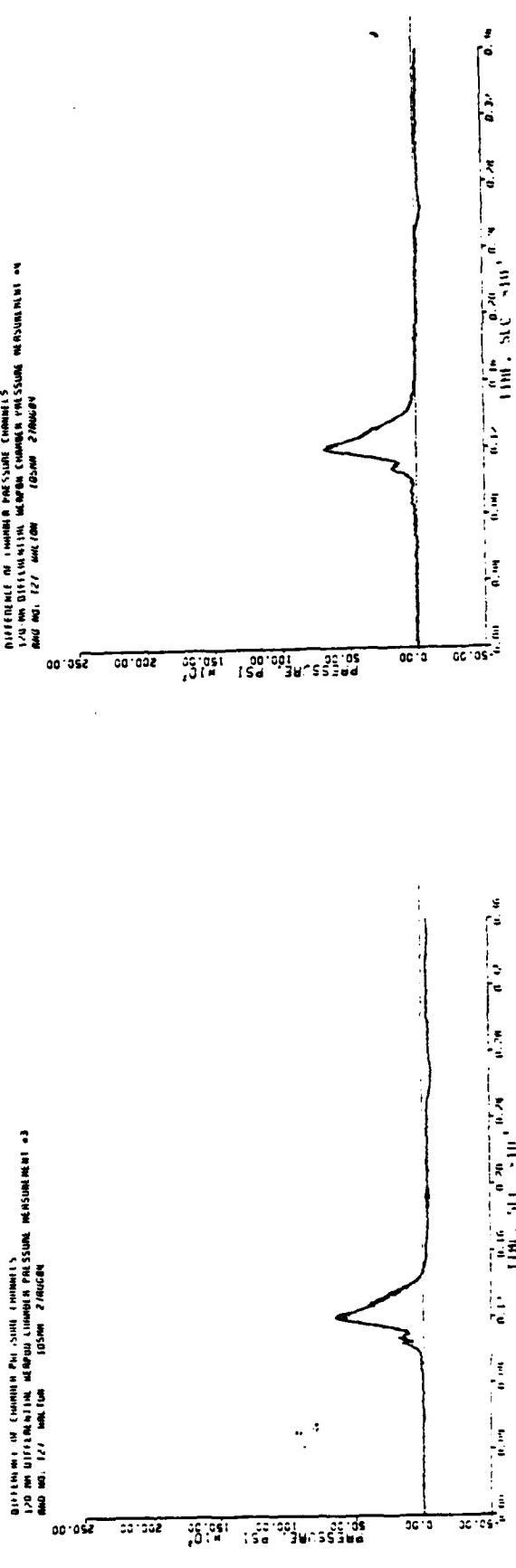
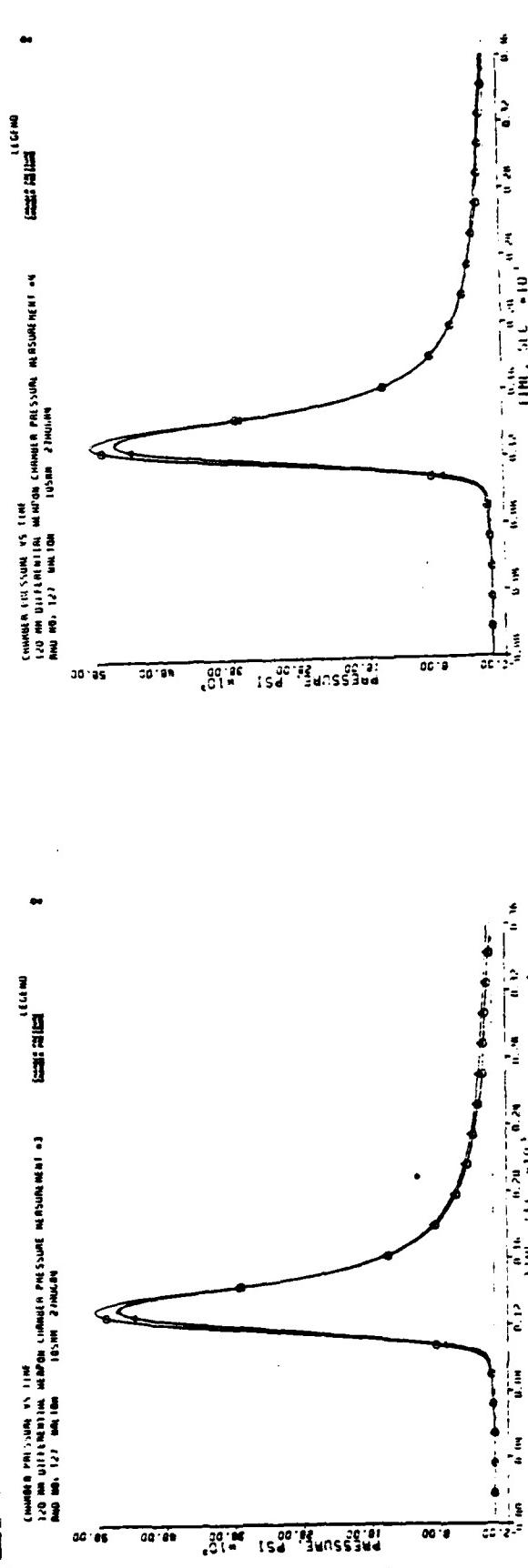


Figure 2-3-1b. Round No. T27.

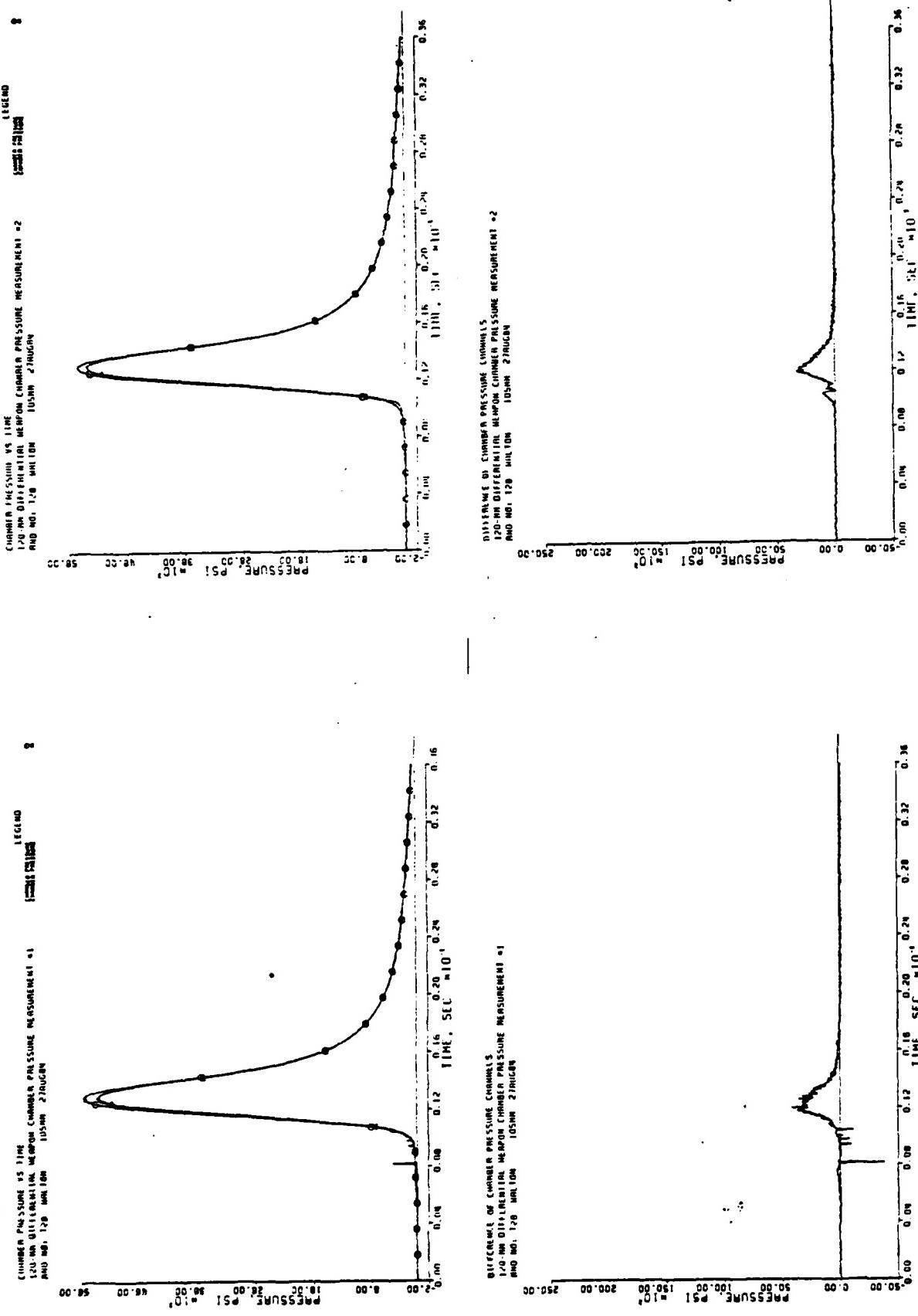
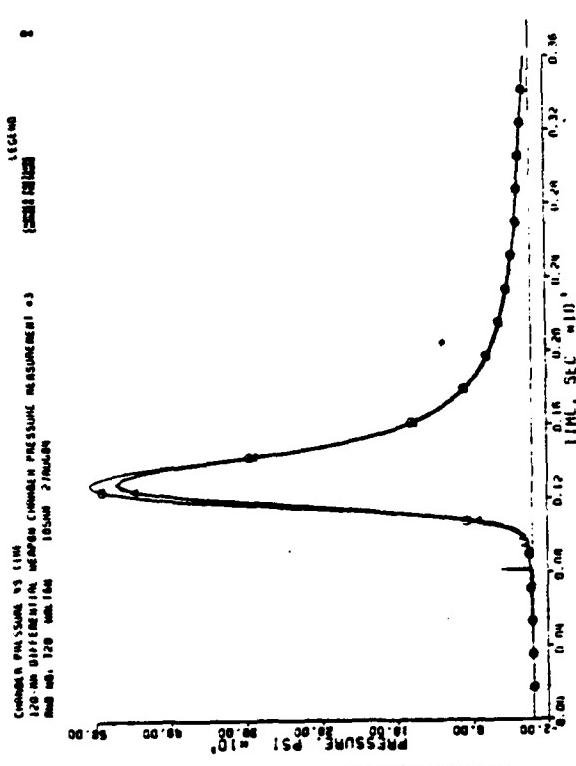


Figure 2.3-2a. Round No. T28.



DIFFERENTIAL OF CHAMBER PRESSURE CHANNEL 1.5  
120 MM DIFFERENTIAL MEASUREMENT CHANNEL PRESSURE MEASUREMENT = 0  
MM NO. 120 MM 105MM 105MM 2 THROAT



DIFFERENCE OF CHAMBER PRESSURE CHANNEL 1.5  
120 MM DIFFERENTIAL MEASUREMENT CHANNEL PRESSURE MEASUREMENT = 0  
MM NO. 120 MM 105MM 105MM 2 THROAT

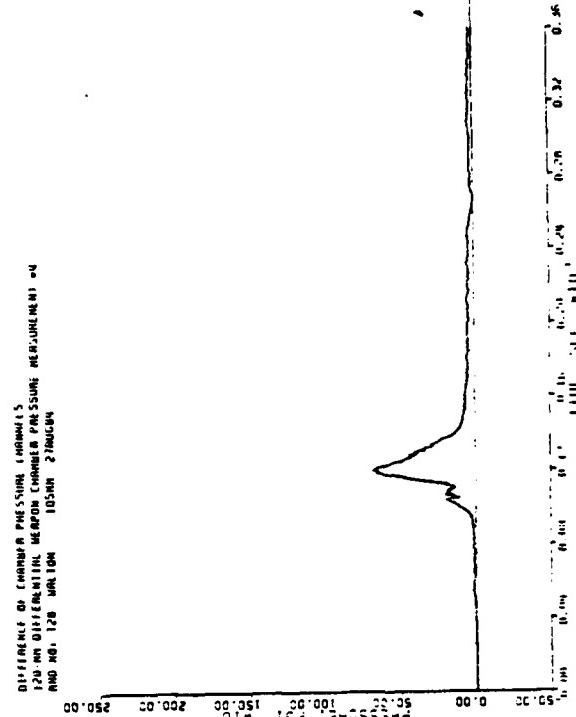
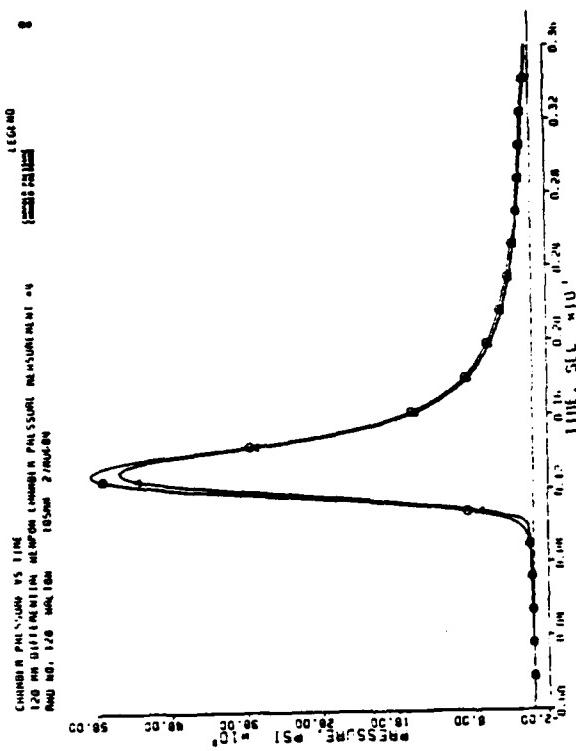


Figure 2.3-2b. Round No. T28.

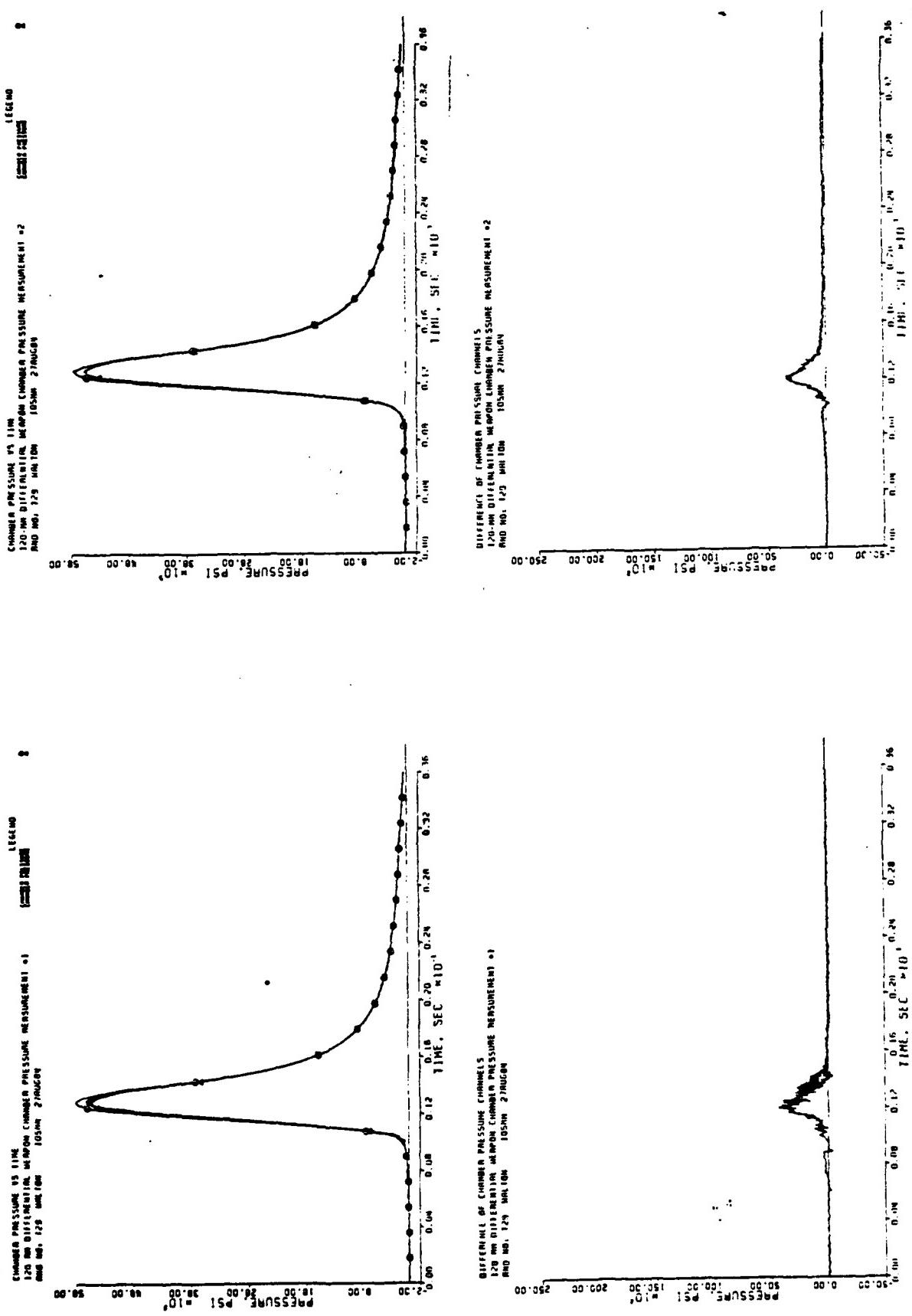


Figure 2.3-3. Round No. T29.

2.3 (Cont'd)

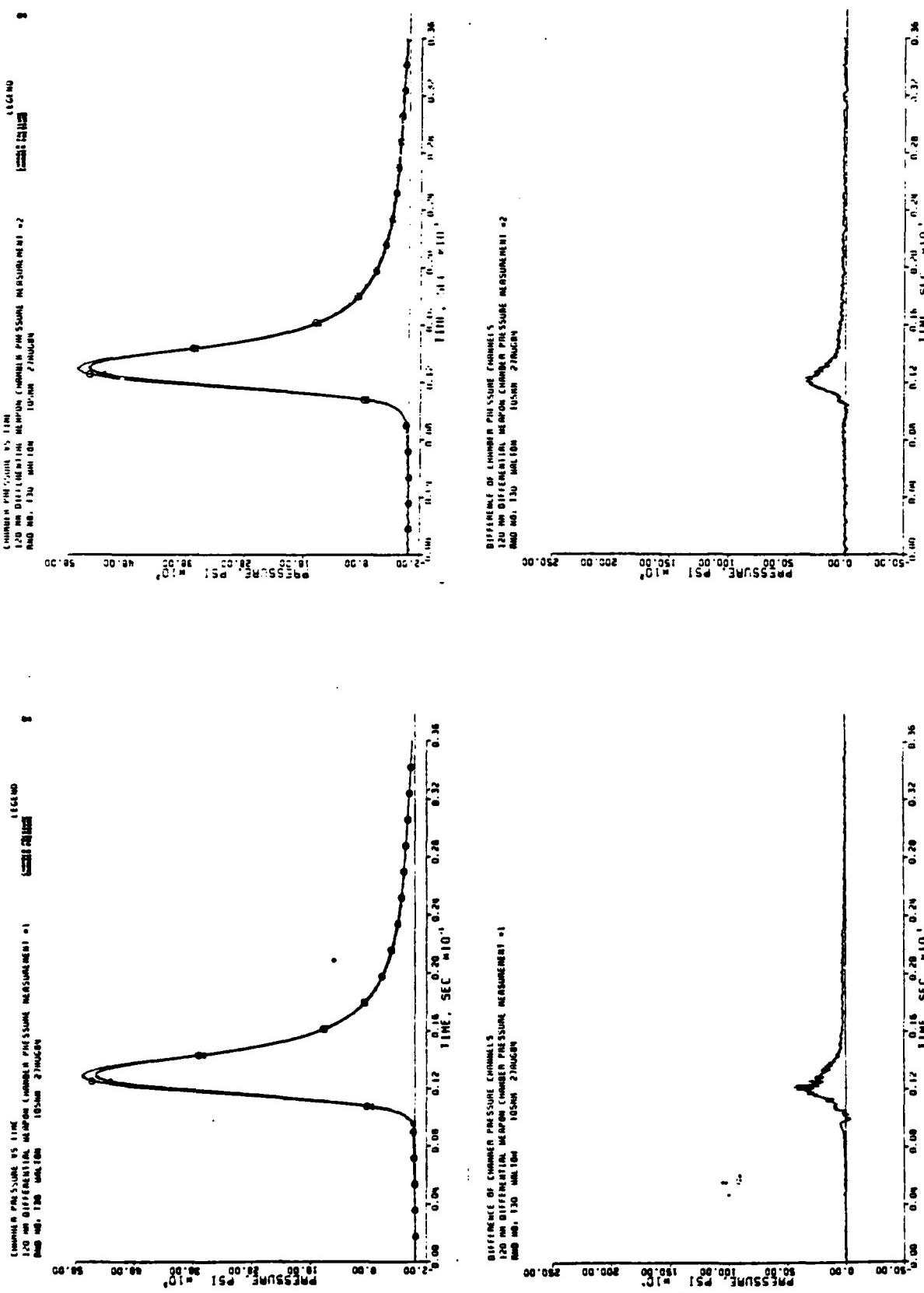


Figure 2.3-4a. Round No. T30.

2.3 (Cont'd)

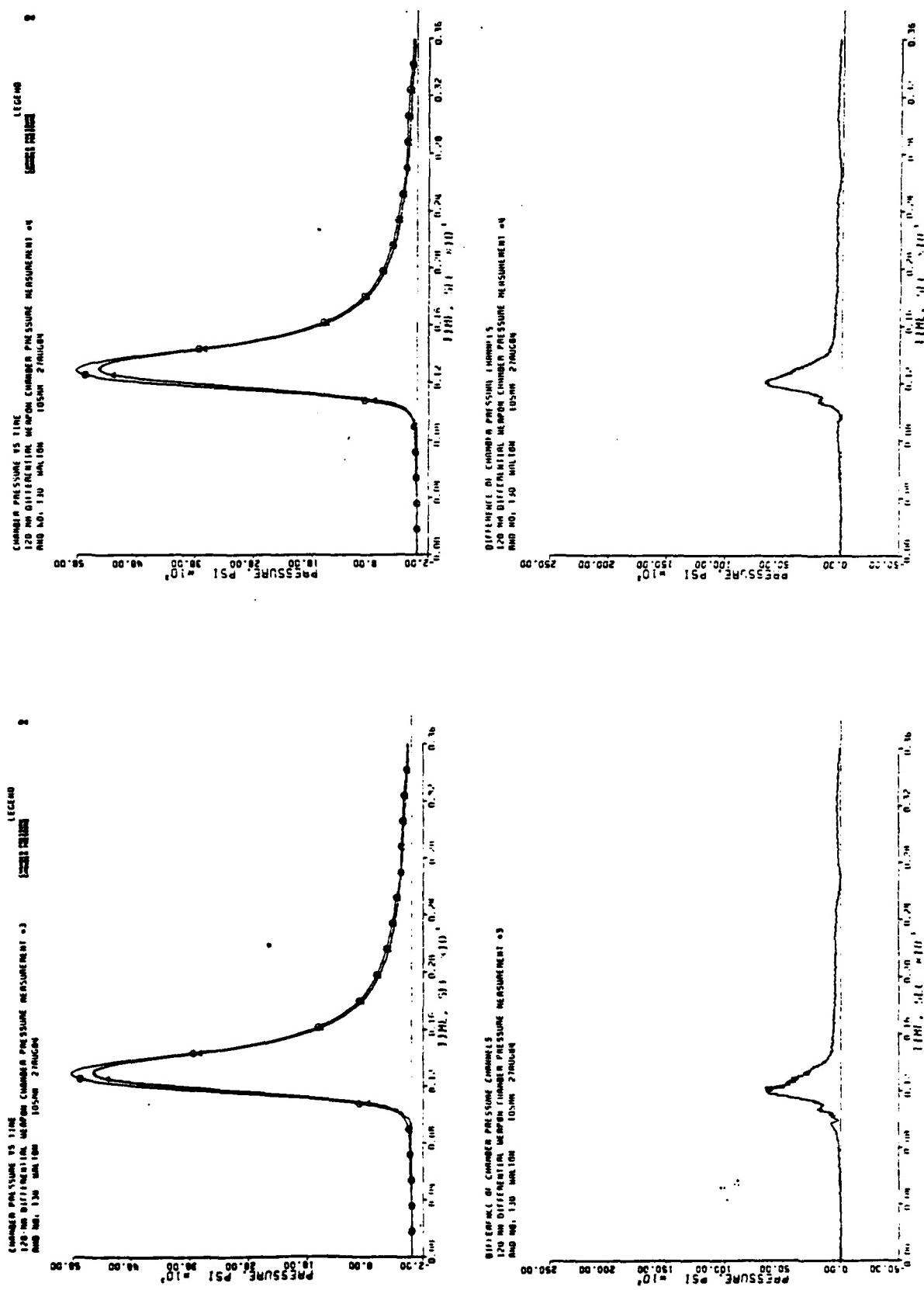


Figure 2.3-4b.. Round No. T30.

2.3 (Cont'd)

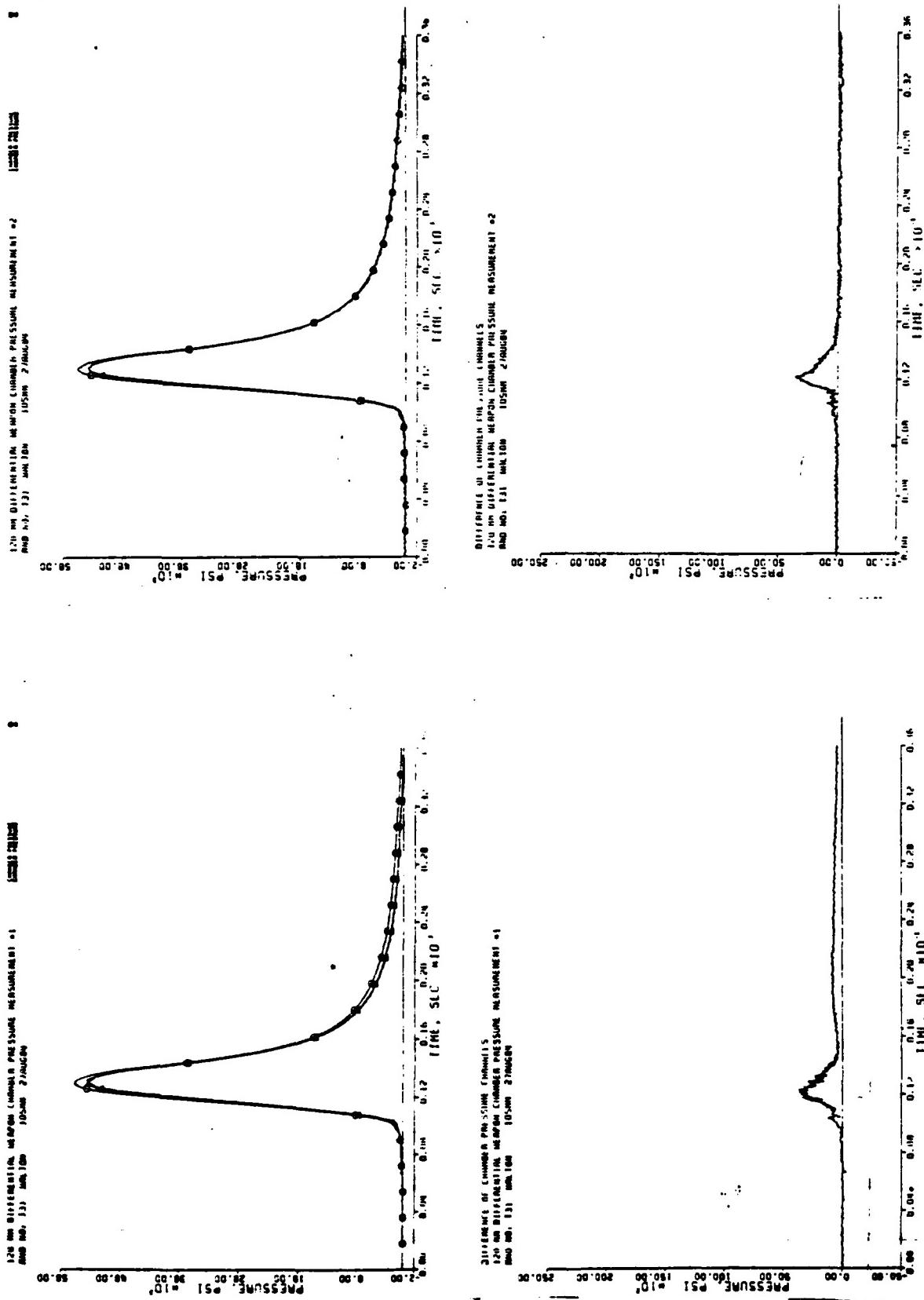


Figure 2.3-5a. Round No. T31.

2.3 (Cont'd)

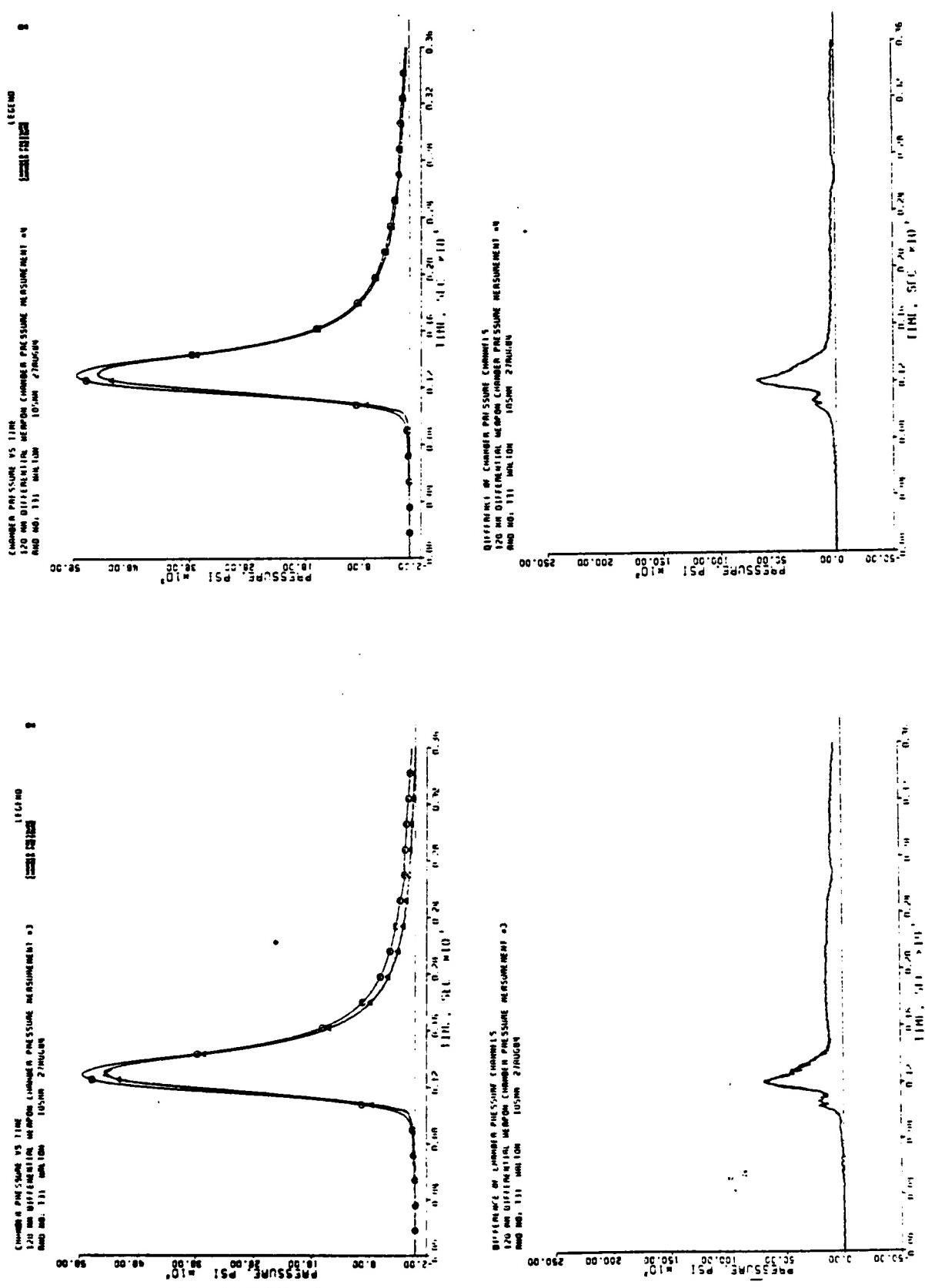
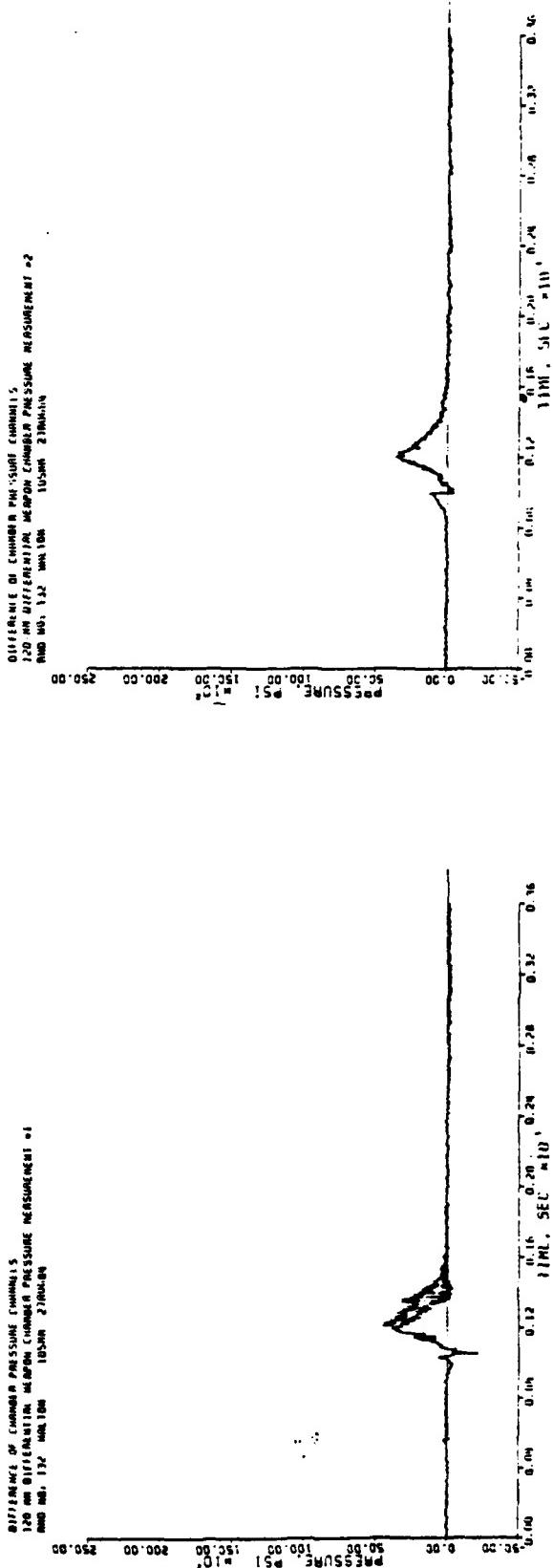
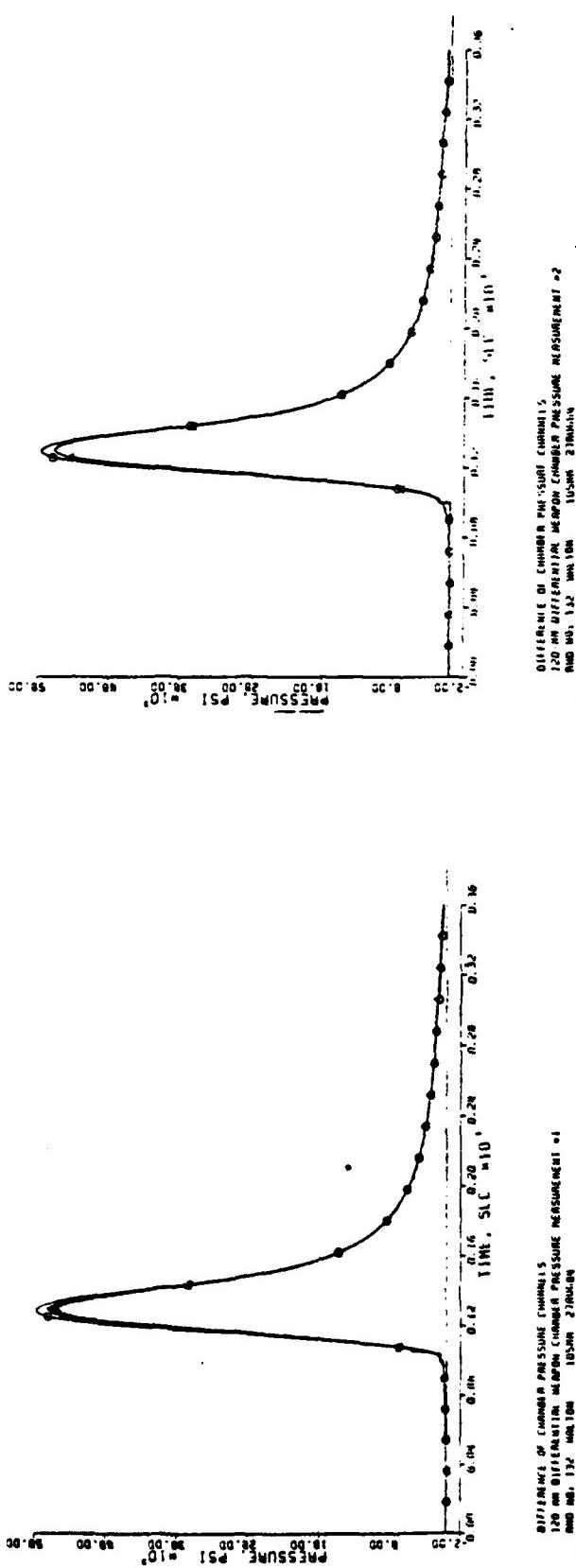


Figure 2.3-5b. Round No. T31.

### 2.3 (Cont'd)



**Figure 2.3-6.. Round No. - T32.**

## 2.4 PHASE Id. ROUNDS 33 THROUGH 38, TUBE 25970

Yuma T-8 gage No. 50 was mounted in the rear gage position, and T-8 gage No. 51 was mounted in the forward gage position. Kistler 504 charge amplifiers were used for the Yuma T-8 gages throughout this phase of firing. Kistler gage No. 168650 was again mounted in the rear position and No. 168659 was in the forward position. The Precision Filters 316 charge amplifier was used for the Kistler gages throughout this phase.

High frequency noise is present on the T-8 records. When the T-8 gage positions are changed after round 35, a large positive offset occurs on the differential record for round 36. This offset is largely attributable to the forward gage. The differential record for round 37 has some variation about the zero baseline but is acceptable, then round 38 exhibits substantial negative offset. This performance is consistent with the seemingly unpredictable nature of differential records.

The T-8 gage differential peak pressures average approximately 900 psi lower after changing gage positions. Switching T-8 gage positions also improved agreement with peak differential pressures produced by the Kistler gages. It is interesting to note that the improved agreement does not result from better agreement between the T-8 and Kistler forward and rear peak pressures; the peak pressures from the T-8 gages are consistently higher than those produced by the Kistler gages. This example illustrates the possibility that peak differential pressures during a phase of firing may be in agreement with historical records for a certain type of ammunition, but that the corresponding peak pressures are not in agreement.

The shapes and amplitudes of the differential plots suggest that the difference in time constants of the Kistler and Precision Filters charge amplifiers does not make a noticeable difference in gage performance. In many cases it appears that the most reliable feature of a differential plot is the general shape of the trace. Round 37 shows the T-8 differential and the 6211 differential. Despite noise, a difference in peak differential pressures, and variation about the zero baseline, the major portion of the records are similar. This is an interesting result, considering the process of deriving the differential plot from two relatively large signals.

TABLE 2.4-1. CHAMBER PRESSURE DATA - PHASE Id

105-mm Tank Gun  
Tube SN 25970  
Cartridge: M392A2  
Temperature: +70° F

Id No.	T-8 No. 50			T-8 No. 51			Kistler No. 168620			Kistler No. 168659			ES15 No. 27			Maximum Initial +ΔP, psi		
	Ch 1	AMP Position	Ch 2	AMP Position	Ch 3	AMP Position	Ch 4	AMP Position	Ch 5	AMP Position	Gage Cage	Channels 1 or 2	Channels 3 and 4	Channels 1 and 2	Channels 3 and 4	Base - Forward	Base - Rearward	
<b>Date Fired: 27 August 1984</b>																		
T33	56.3	504	Rear	56.1	504	Forward	56.7	316	Rear	56.8	316	Forward	58.6	316	Base	4770	3370	6500
T34	57.4	504	Rear	55.5	504	Forward	56.0	316	Rear	54.7	316	Forward	58.1	316	Base	4420	2900	6700
T35	58.4	504	Rear	56.8	504	Forward	57.1	316	Rear	55.3	316	Forward	NR	316	-	4520	3790	6500
T36	56.7	504	Forward	57.6	504	Rear	56.8	316	Rear	55.5	316	Forward	58.7	316	Base	3260	3780	NA
<b>Date Fired: 28 August 1984</b>																		
T37	55.9	504	Forward	56.8	504	Rear	55.8	316	Rear	54.0	316	Forward	57.7	316	Base	3440	3930	6100
T38	57.4	504	Forward	58.7	504	Rear	57.8	316	Rear	55.9	316	Forward	NR	316	-	4350	3570	NA

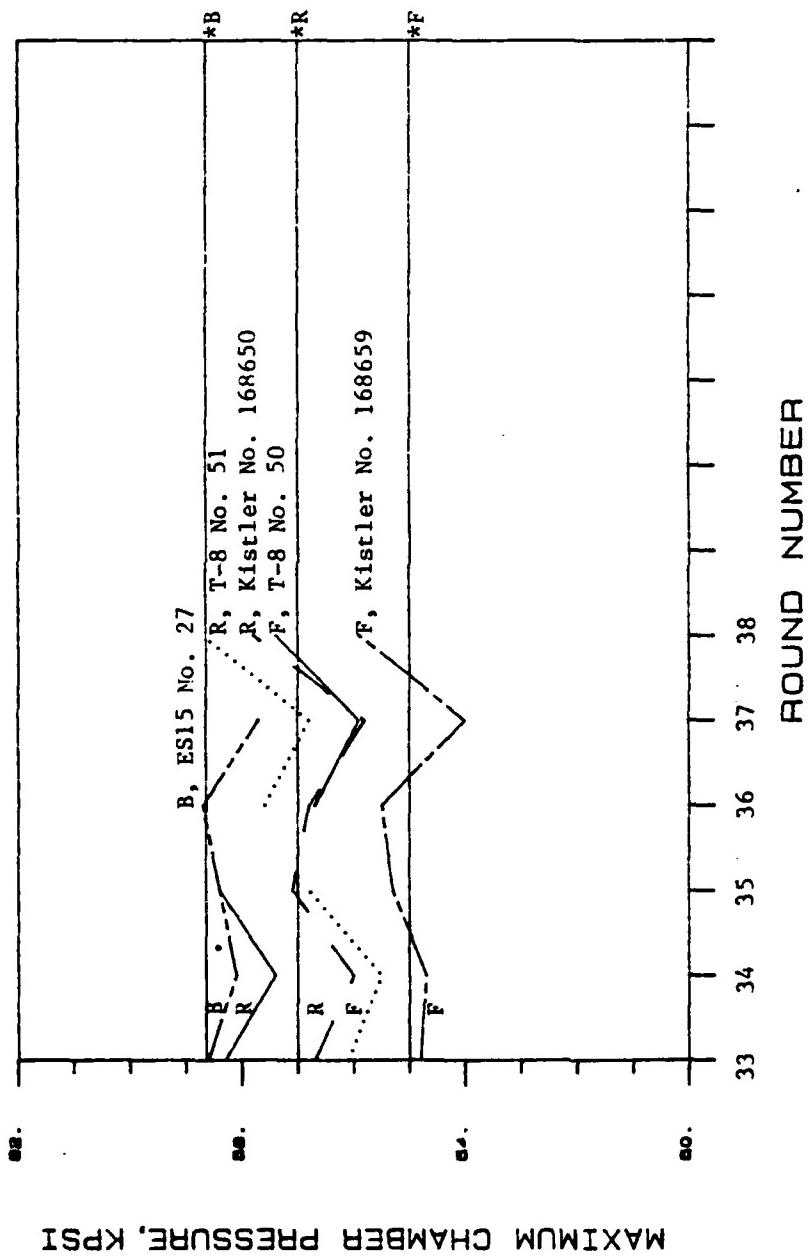
NA = Not applicable.

NR = Not recorded.

Ch = Channel.

.4 (Cont'd)

MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER



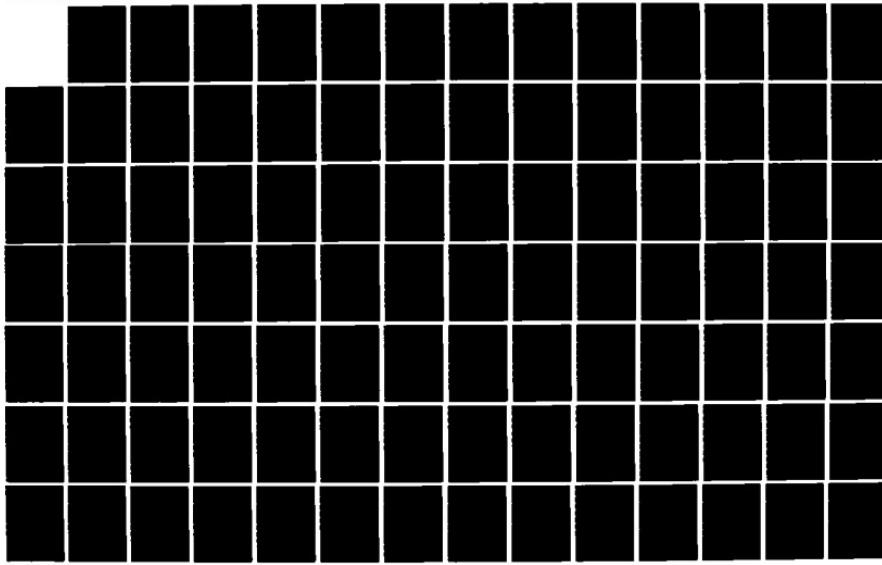
F = Forward gage position.  
R = Rear gage position.  
B = Base gage position.  
\* = Average pressure throughout test, all gages, all rounds fired.

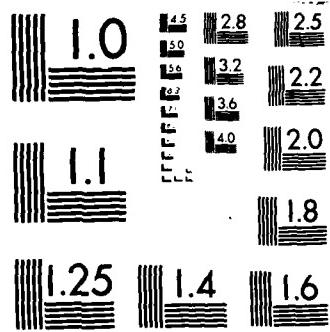
Figure 2.4-1(1). Maximum chamber pressure.

AD-A156 775    METHODOLOGY INVESTIGATION OF 120-MM DIFFERENTIAL WEAPON    2/4  
CHAMBER PRESSURE MEASUREMENT(U) ARMY COMBAT SYSTEMS  
TEST ACTIVITY (PROV) ABERDEEN PROVING GRO.

UNCLASSIFIED    V A BETZOLD ET AL. FEB 85 USACSTA-6163

F/G 14/2    NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS 1963-A

## MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER

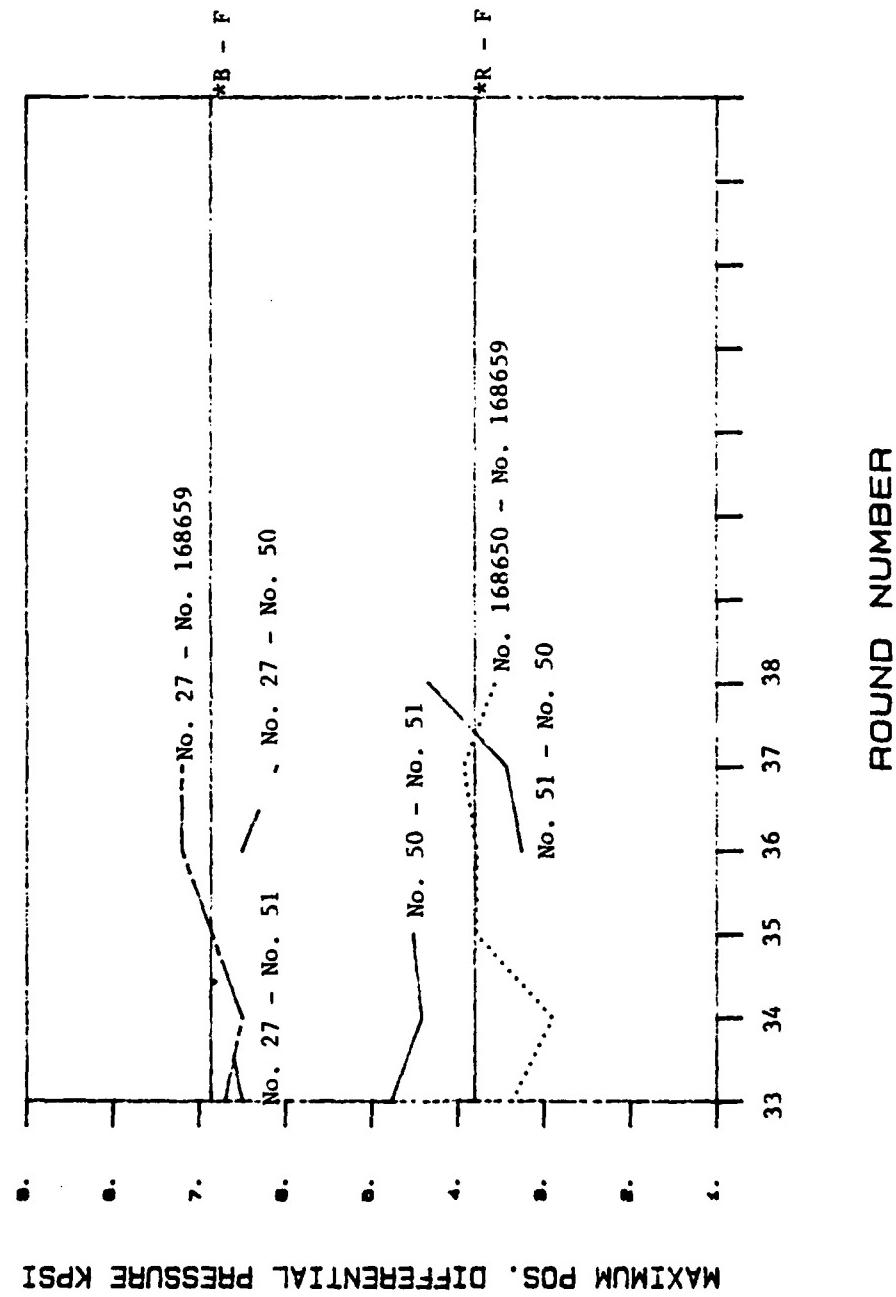


Figure 2.4-1(2). Maximum positive differential pressure.

2.4 (Cont'd)

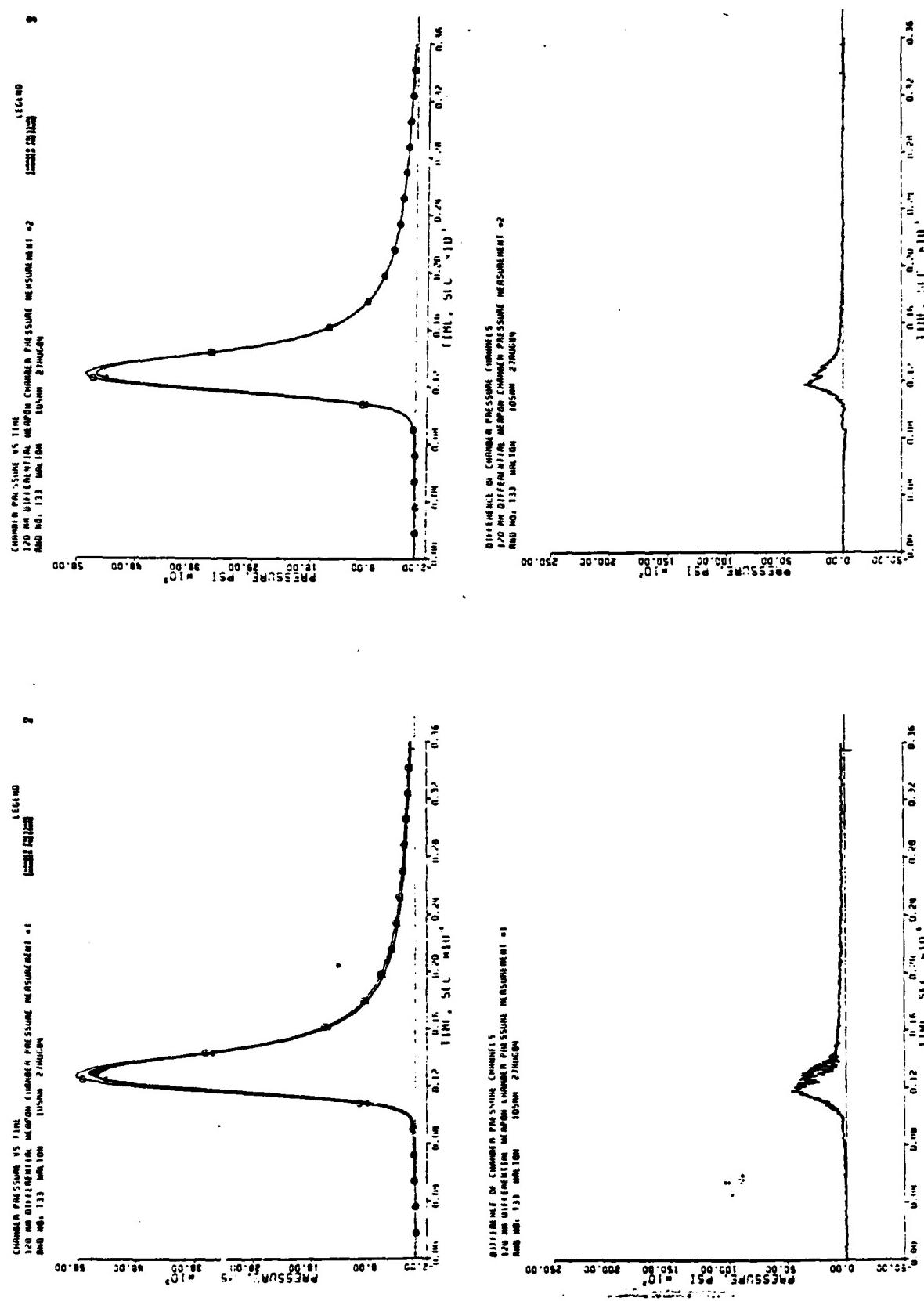
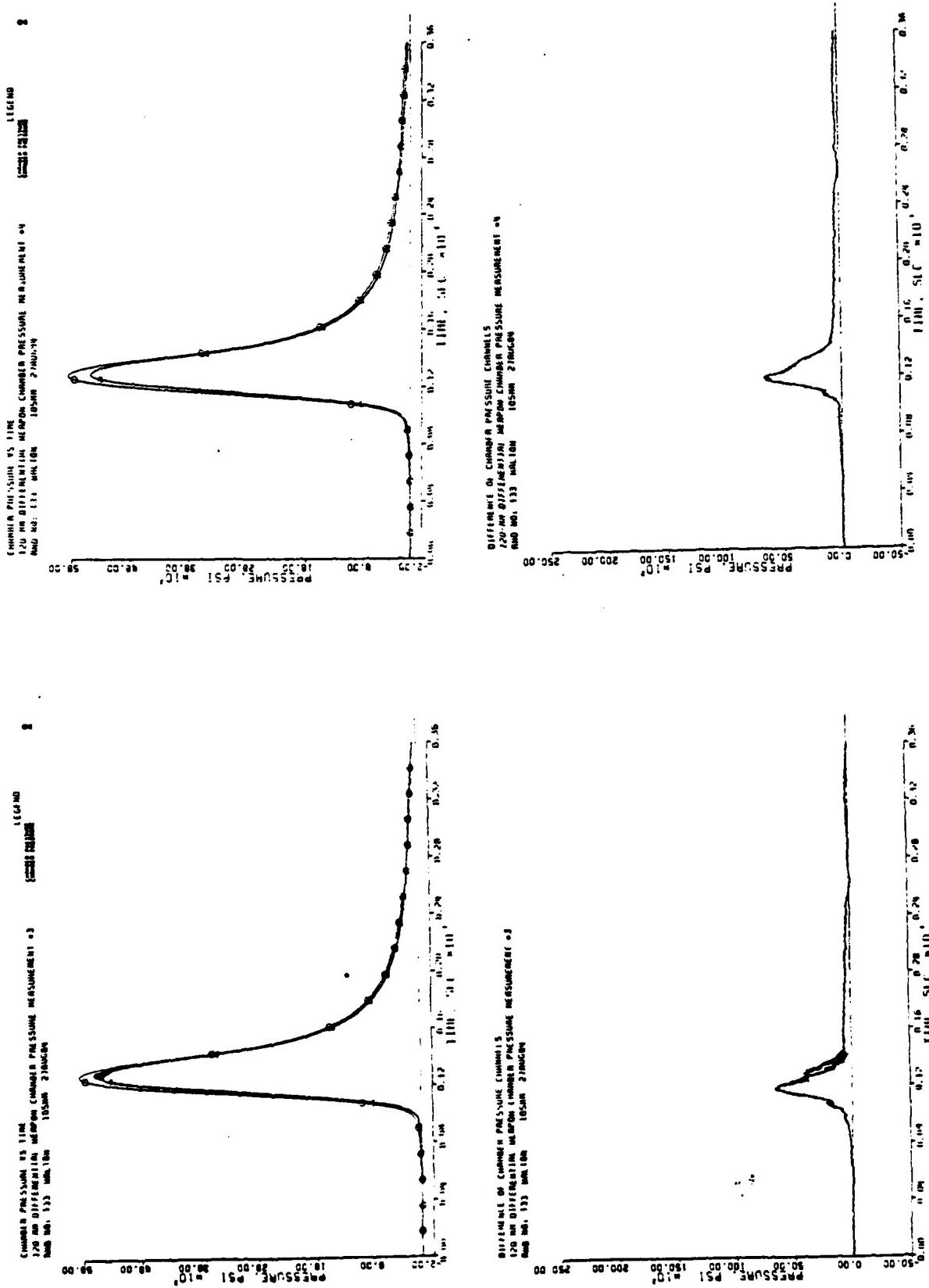


Figure 2.4-1a. Round No. T33.

2.4 (Cont'd)



## 2.4 (Cont'd)

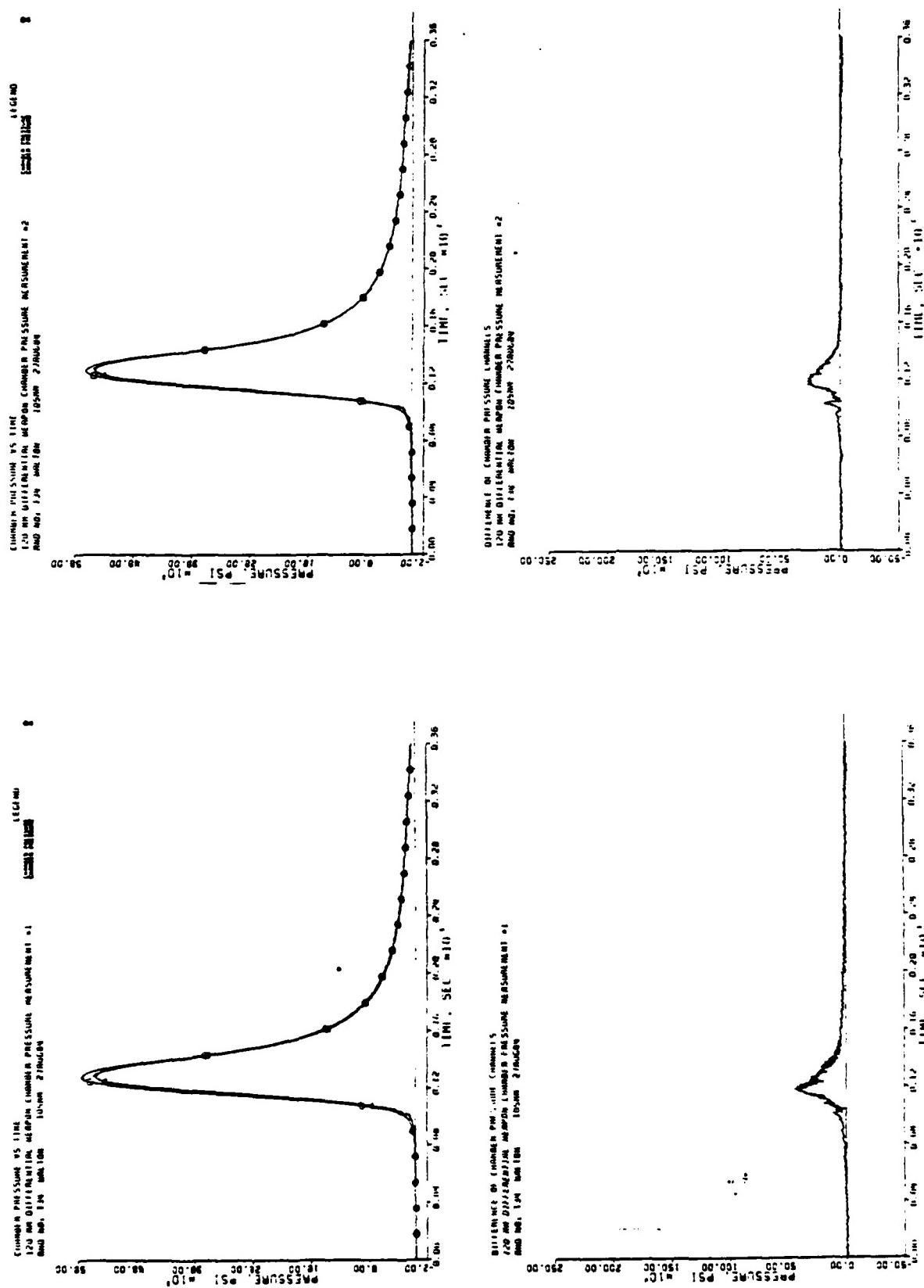


Figure 2.4-2a. Round No. T34.

2.4 (Cont'd)

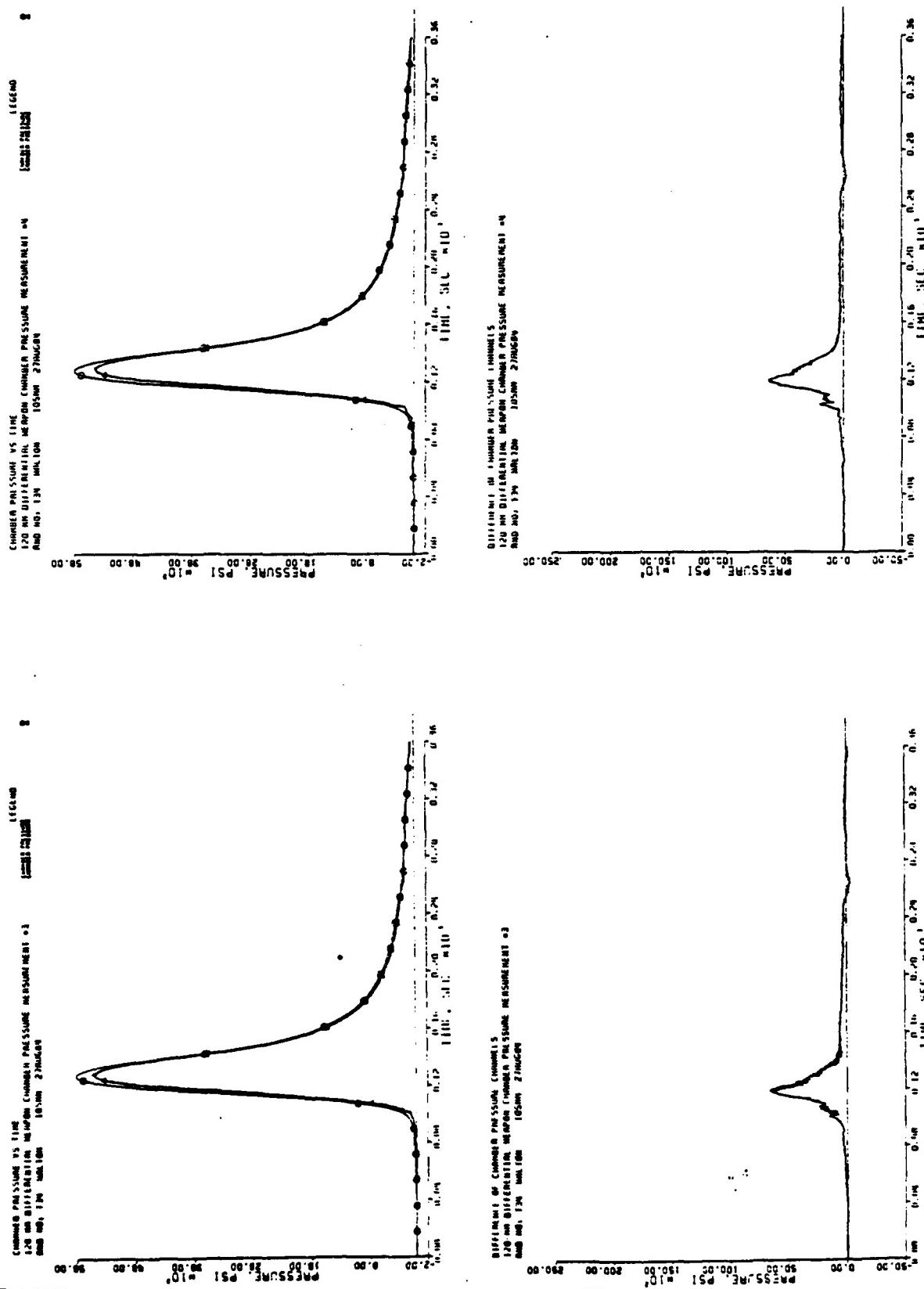


Figure 2.4-2b. Round No. T34.

2.4 (Cont'd)

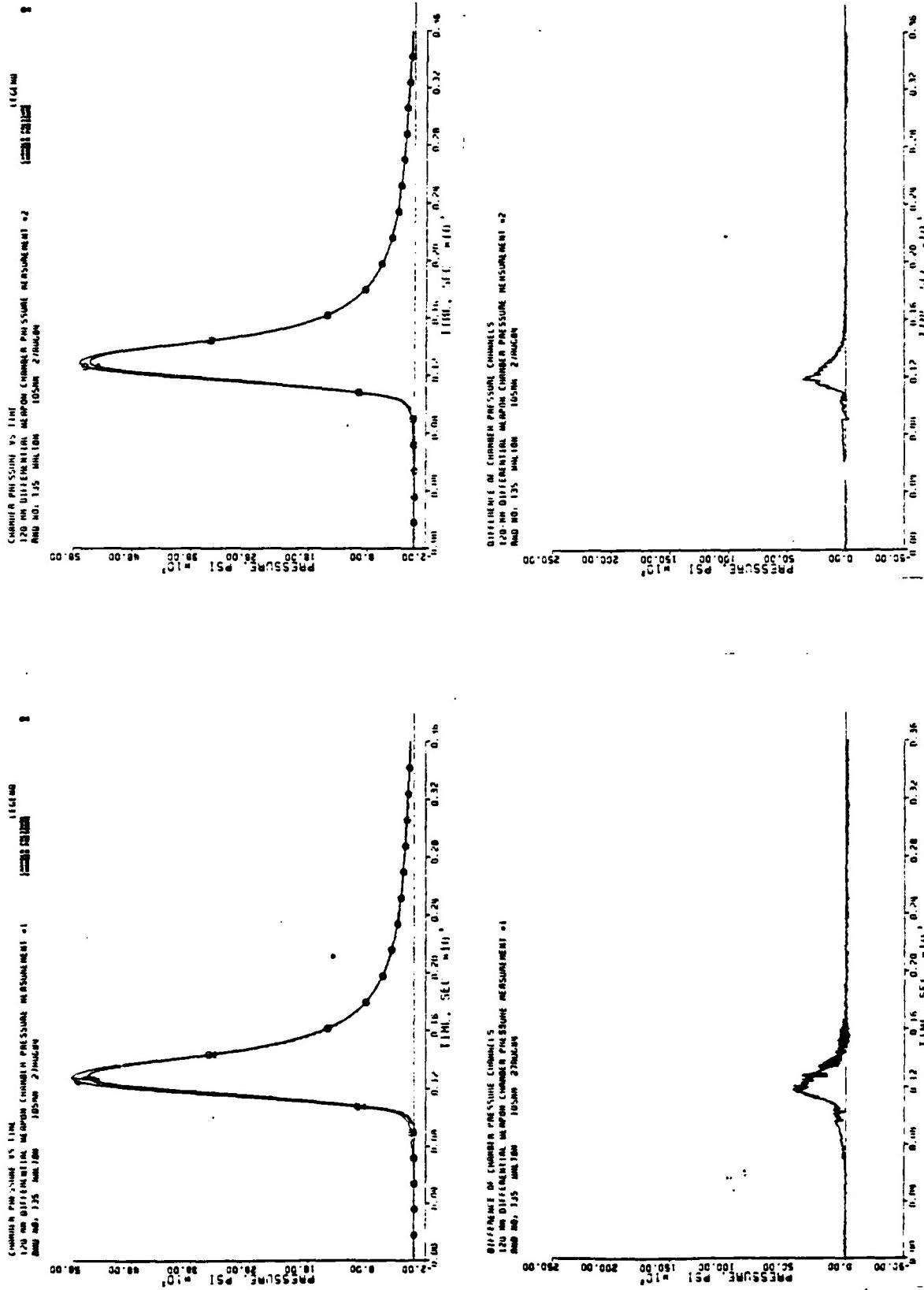


Figure 2.4-3. Round No. T35.

2.4 (Cont'd)

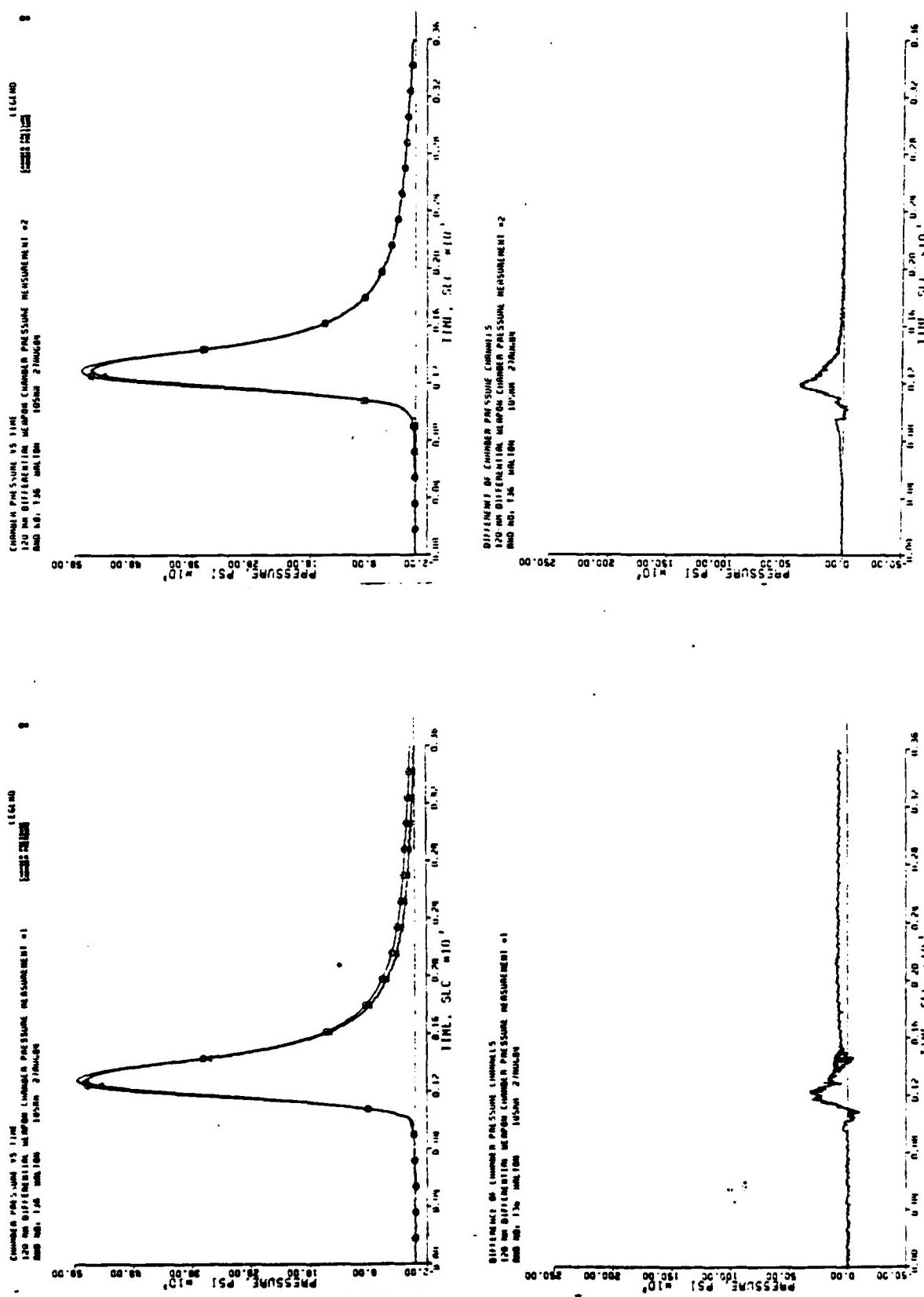


Figure 2.4-4a. — Round No. T36.

2.4 (Cont'd)

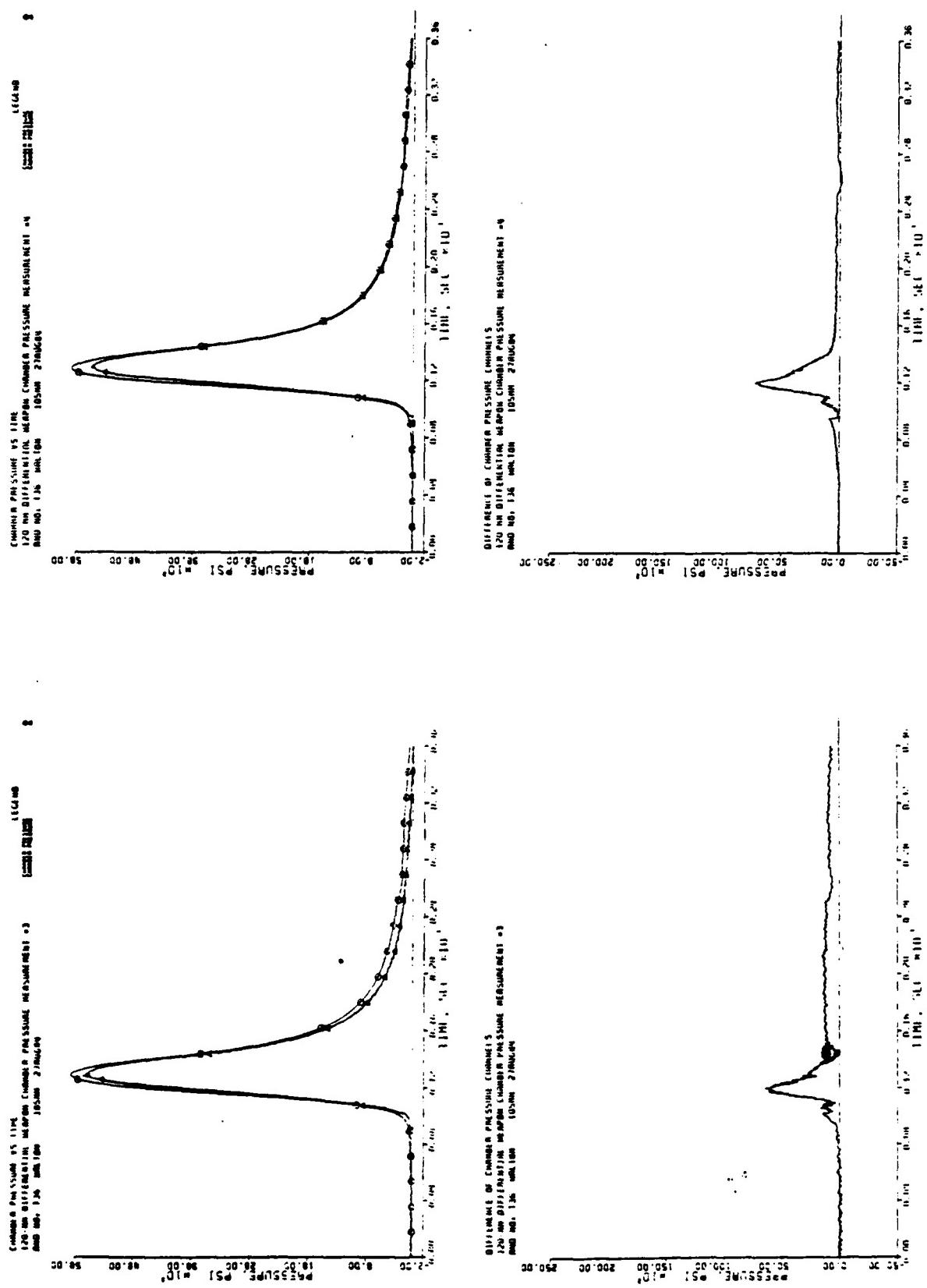


Figure 2.4-4b. Round No. T36.

2.4 (Cont'd)

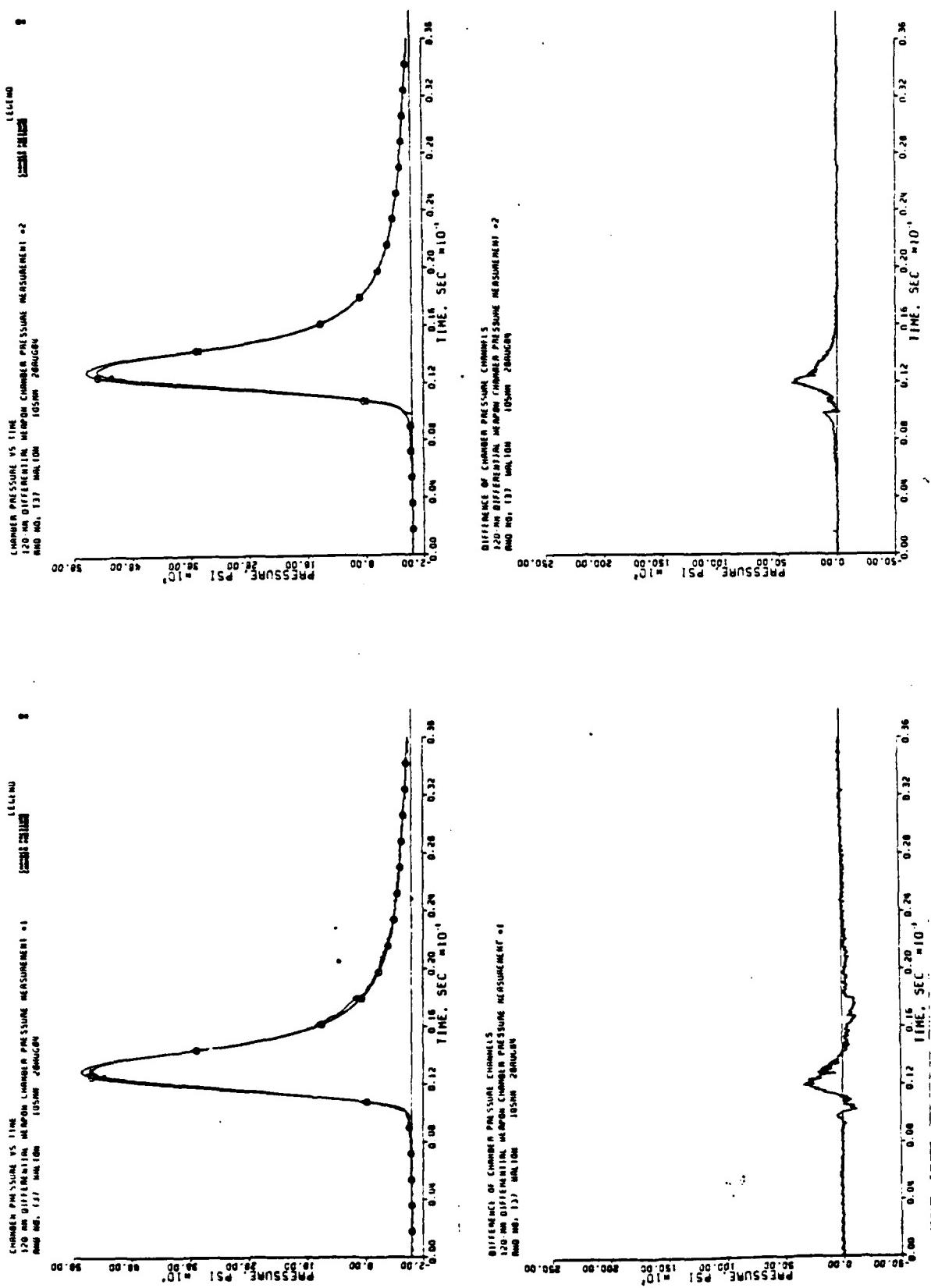


Figure 2.4-5a. Round No. T37..

2.4 (Cont'd)

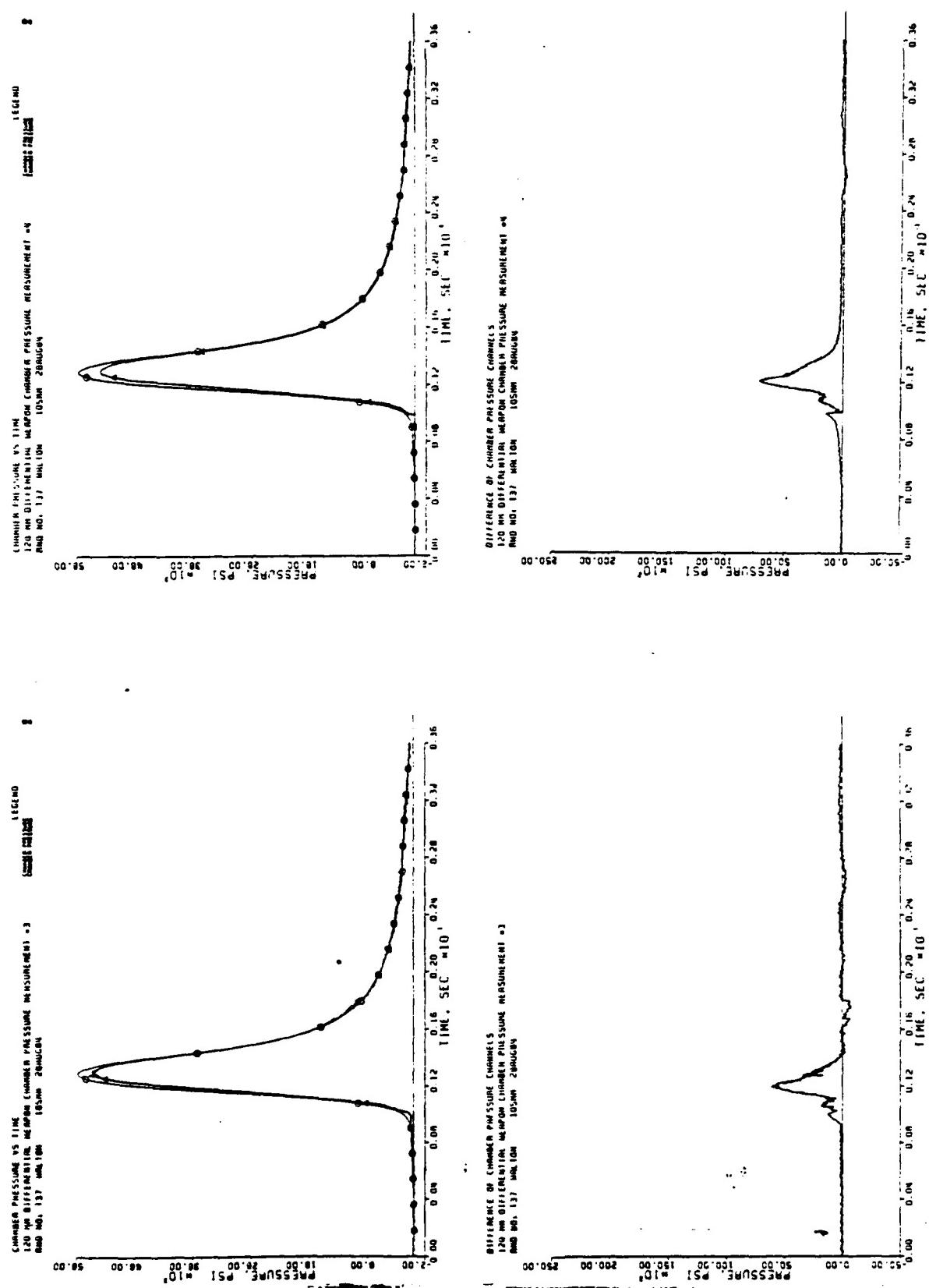


Figure 2.4-5b. Round No. T37.

2.4 (Cont'd)

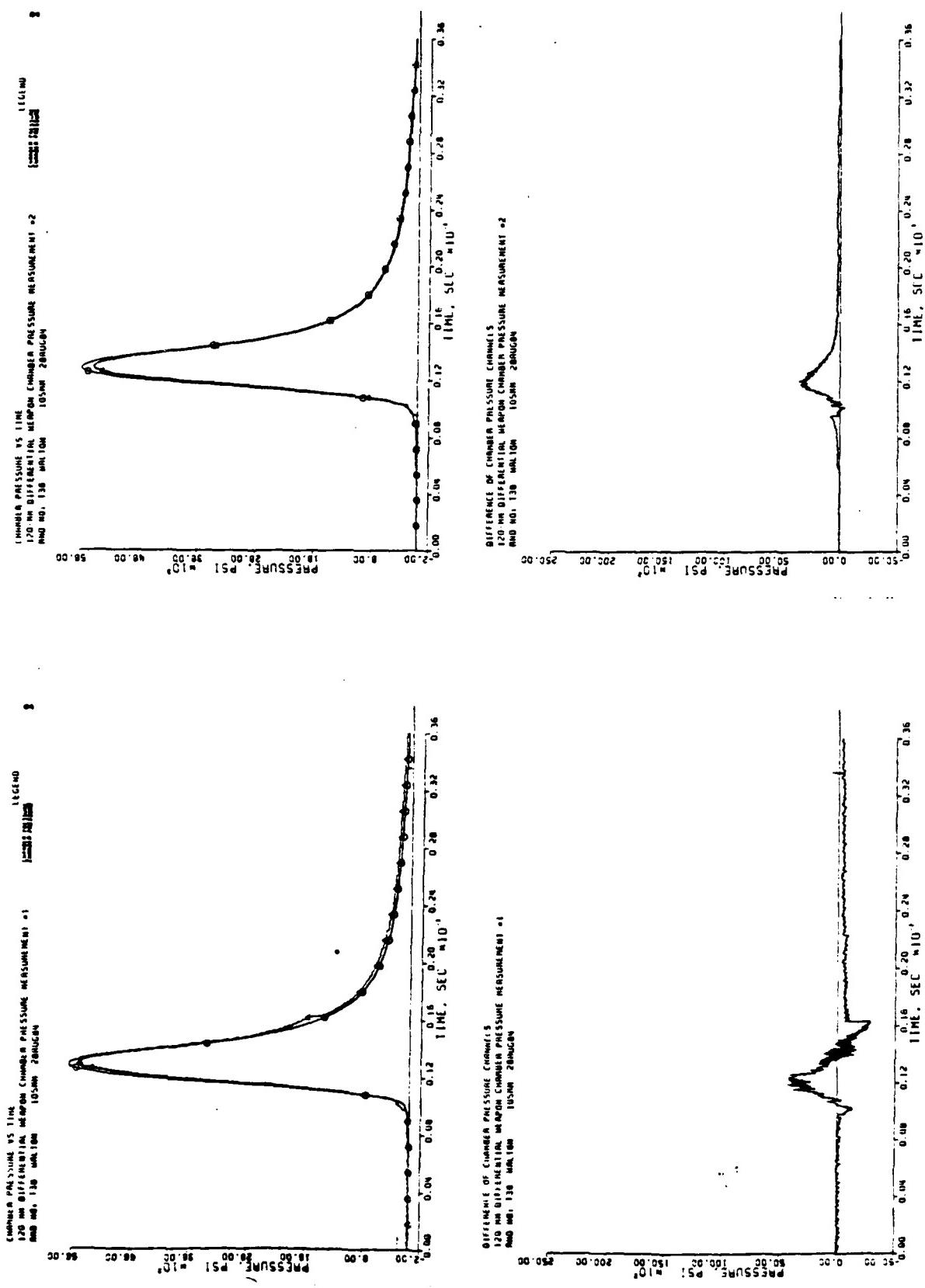


Figure 2.4-6. Round No. T38.

## 2.5 PHASE Ie. ROUNDS 39 THROUGH 47, TUBE 25970

Kistler 6211 gage No. 151647 in adapter No. 3 was mounted in the rear position, and Kistler 6211 No. 151652 in adapter No. 4 was mounted in the forward position. This pair of gages had produced questionable pressure data during a previous firing program. The Precision Filters charge amplifier was used for these gages throughout this phase. Kistler gages 168650 and 168659 remained in the left side of the tube; this phase began with the gages in the same positions as the previous phase of firing. The Precision Filters charge amplifier was used throughout the phase for this pair of gages as well.

The right set of gages produced a classic example of crossover for rounds 39 through 44. Positive peak differential records are low, to the point of being unmistakably wrong. The typical differential peak pressure for the M392A2 round throughout the test has been approximately 3800 psi. The left pair of Kistler gages measure in this range, but the right set produced readings of 1900, 2220, and 1700 psi. The rear gage (Kistler 151647) appears to read too low when compared to the expected rear gage peak pressure levels, and compared to the rear gage performance on the left side of the tube.

When the Kistler gages on the right side are reversed after round 44, the differential peak pressures increase to more than 5000 psi. Gage 151647 continues to read low in the forward position. This gage failed to produce believable data despite the use of an adapter.

The differential performance of gages 151647 and 151652 was not as bad during rounds 1 through 13, and during a normal firing program with no prior knowledge of ammunition performance these results may have been accepted. However, it is likely that personnel in charge of data acquisition would have started changing gages if data such as rounds 39 through 44 were acquired. Under these circumstances, data acquisition personnel could save a great deal of time and expense by maintaining a logbook with narratives describing gage performance under firing conditions. This is presently accomplished by the operator's memory, and is effective only in the short term.

The set of Kistler gages on the left side produced differential pressure records with minimal noise, little offset and believable peak pressures. Peak pressures are also within expected limits for the forward and rear gage, as are the base - forward differential pressures. This pair of gages is an example of a set that would be identified by a BTST operator as good and would continue to be used on successive firing programs.

The effect of the crossover on rounds 39 through 44 suggests that although the peak pressure obtained from differential records with a positive offset were found to be acceptable earlier in this report, the crossover effect may artificially reduce the differential peak pressure. This is a reasonable possibility, since in this case, the rear gage was observed to be reading low. If the front gage is assumed correct, it could exceed the rear gage at certain points in time producing the short duration crossover effect.

2.5 (Cont'd)

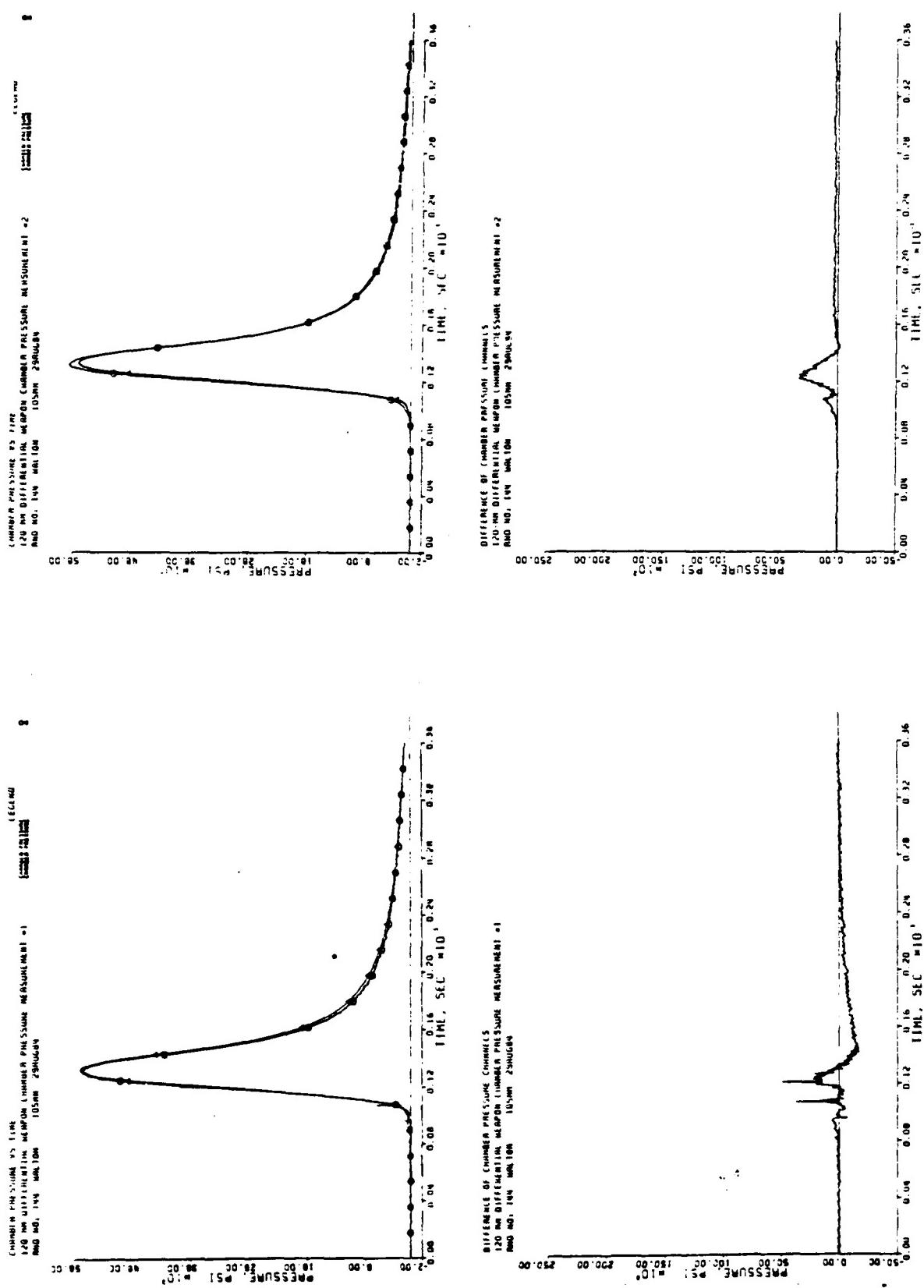
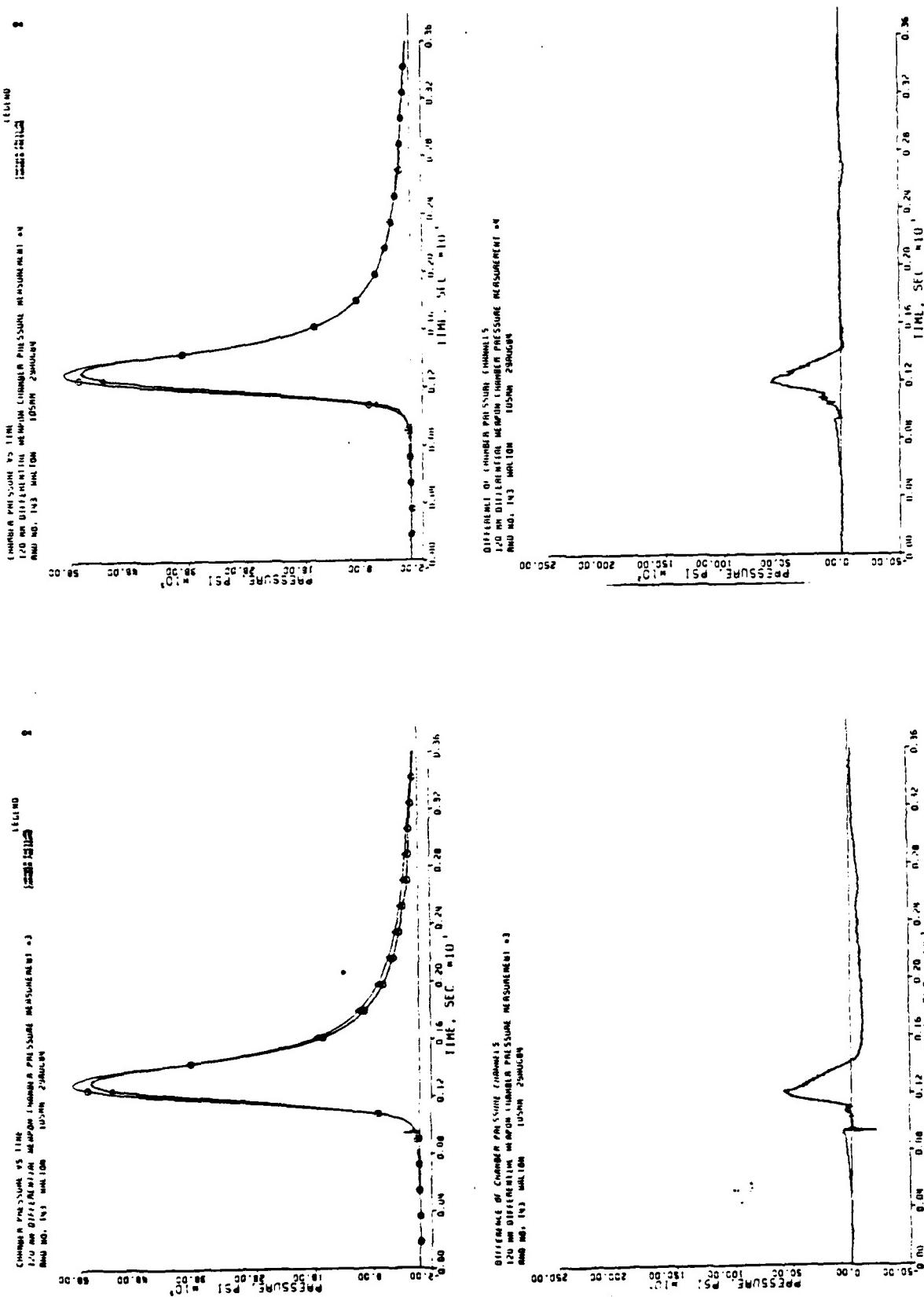


Figure 2.5-6. Round No. T44.

## 2.5 (Cont'd)



**Figure 2.5-5b.** Round No. T43:

2.5 (Cont'd)

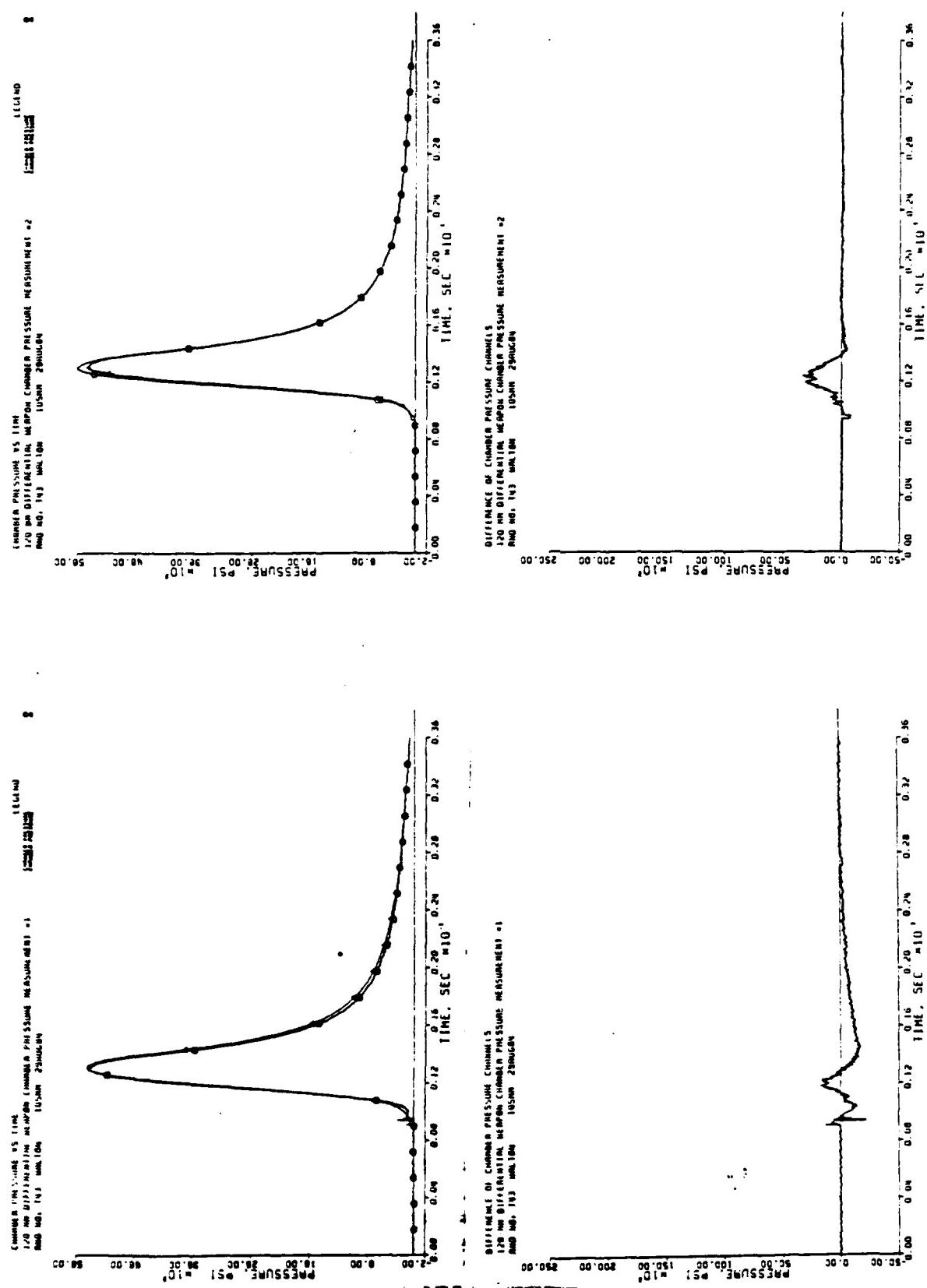


Figure 2.5-5a. Round No. T43.

2.5 (Cont'd)

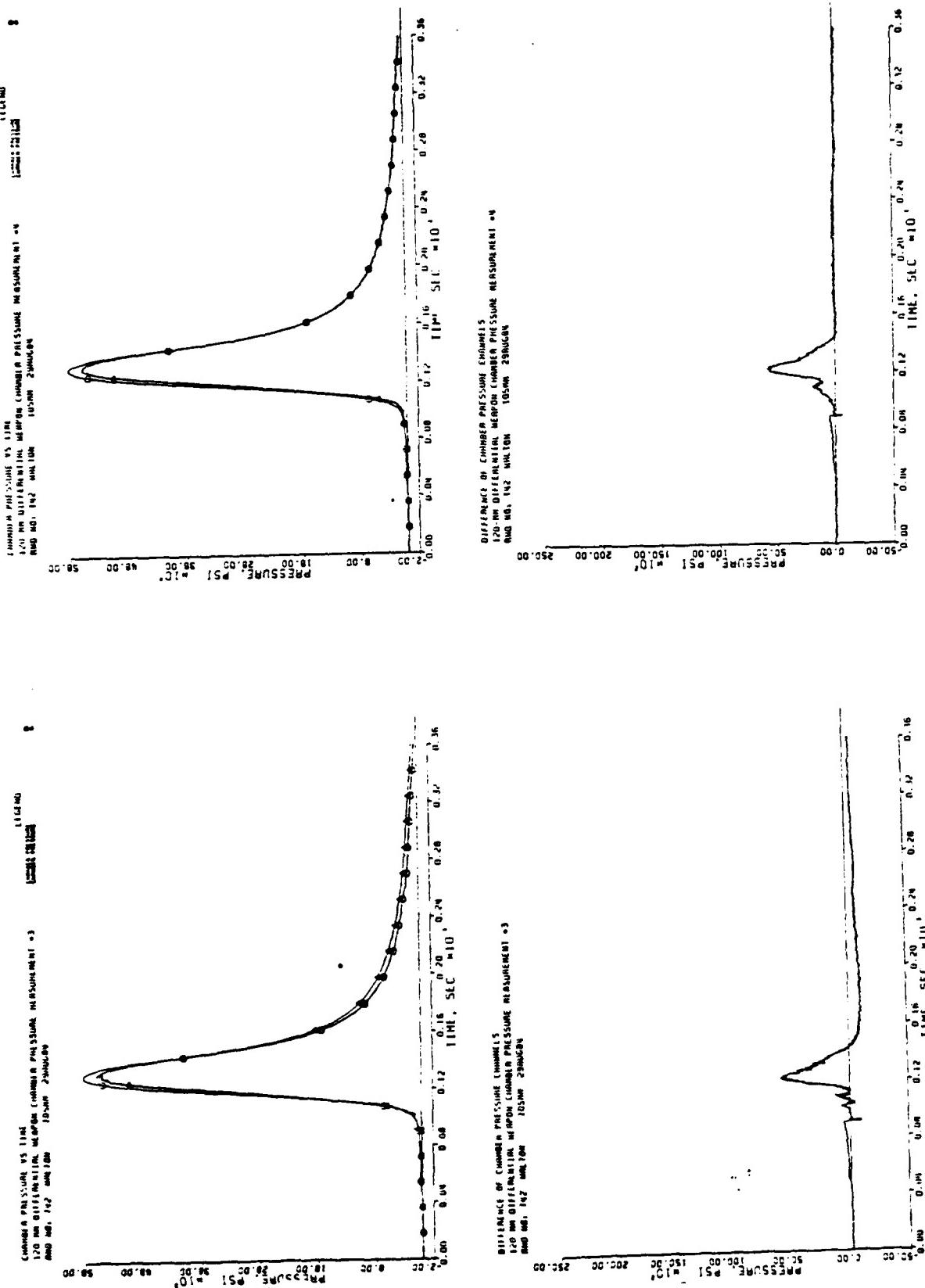


Figure 2.5-4b. Round No. T42.

2.5 (Cont'd)

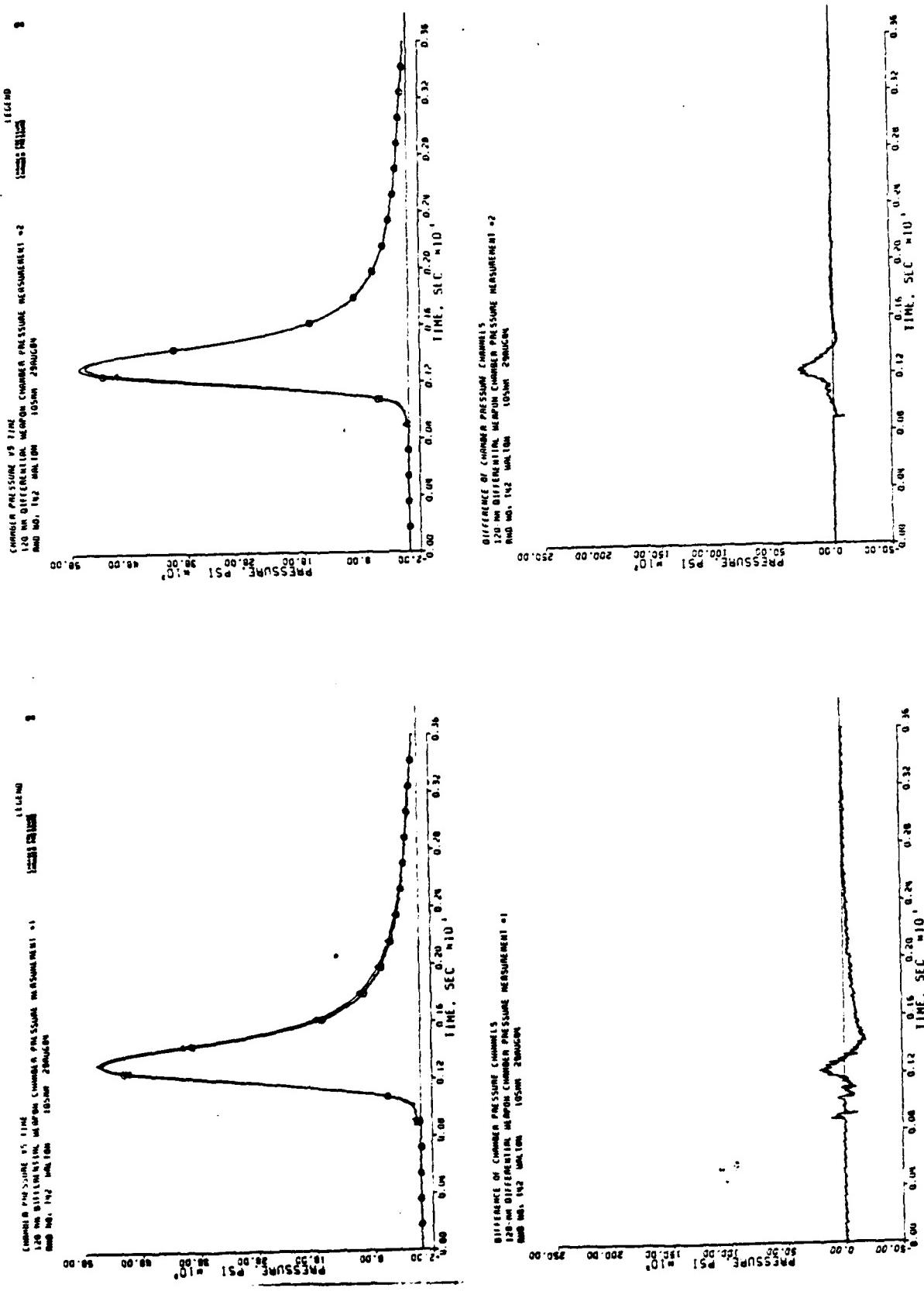


Figure 2.5-4a. Round No. T42.

2.5 (Cont'd)

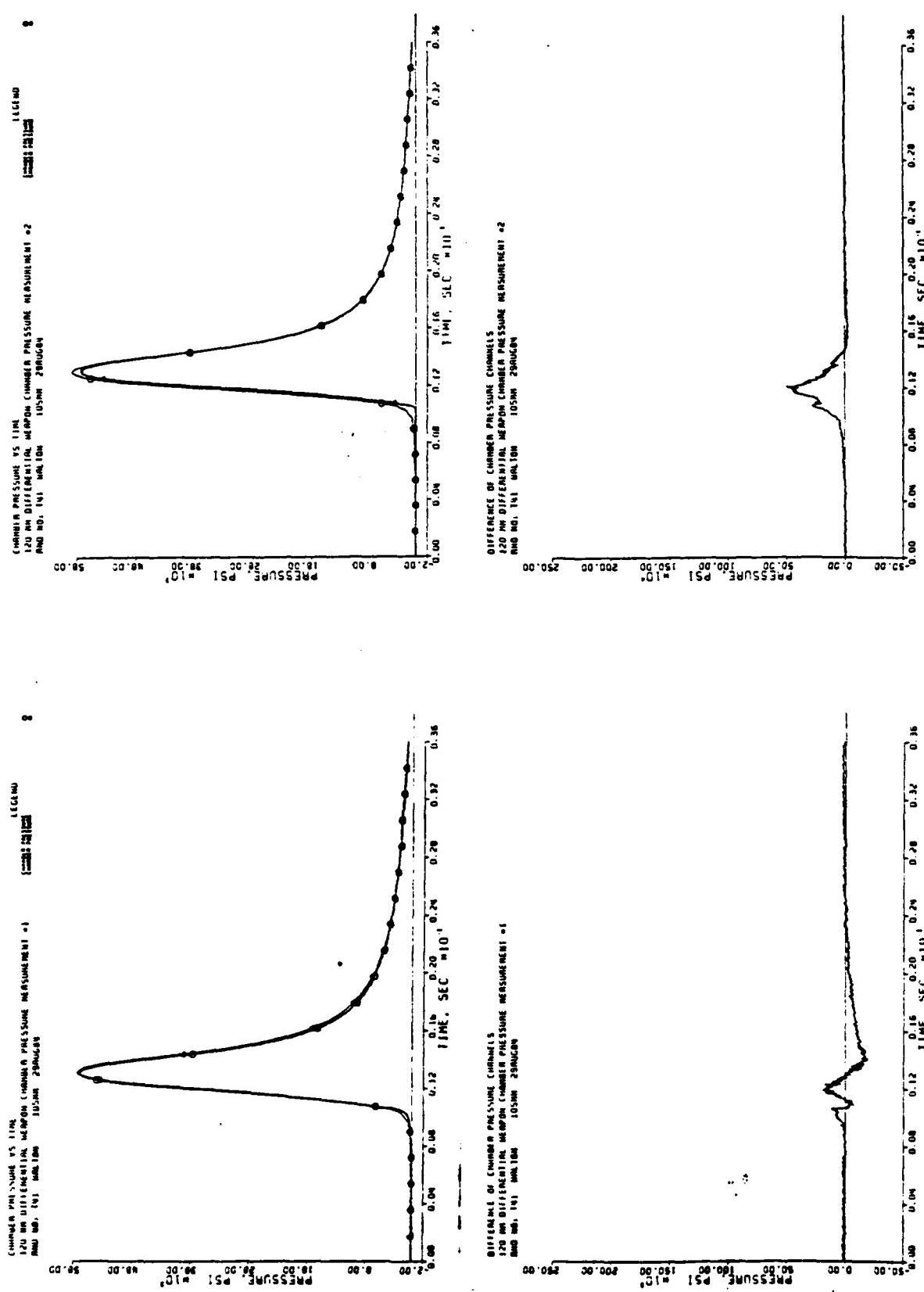
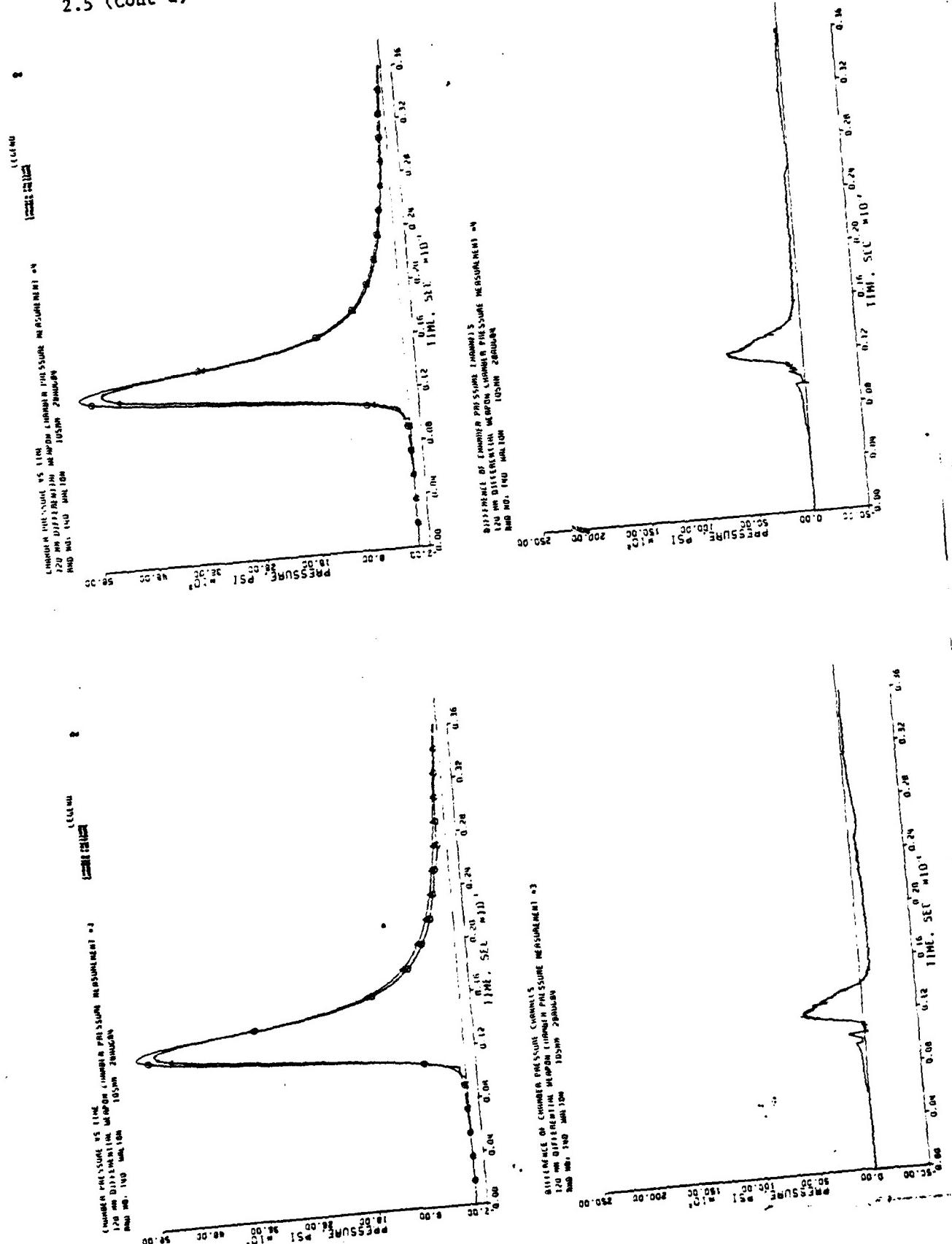


Figure 2.5-3. Round No. T41.

2.5 (Cont'd)



109a

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Figure 2.5-2b. Round No. T40.

2.5 (Cont'd)

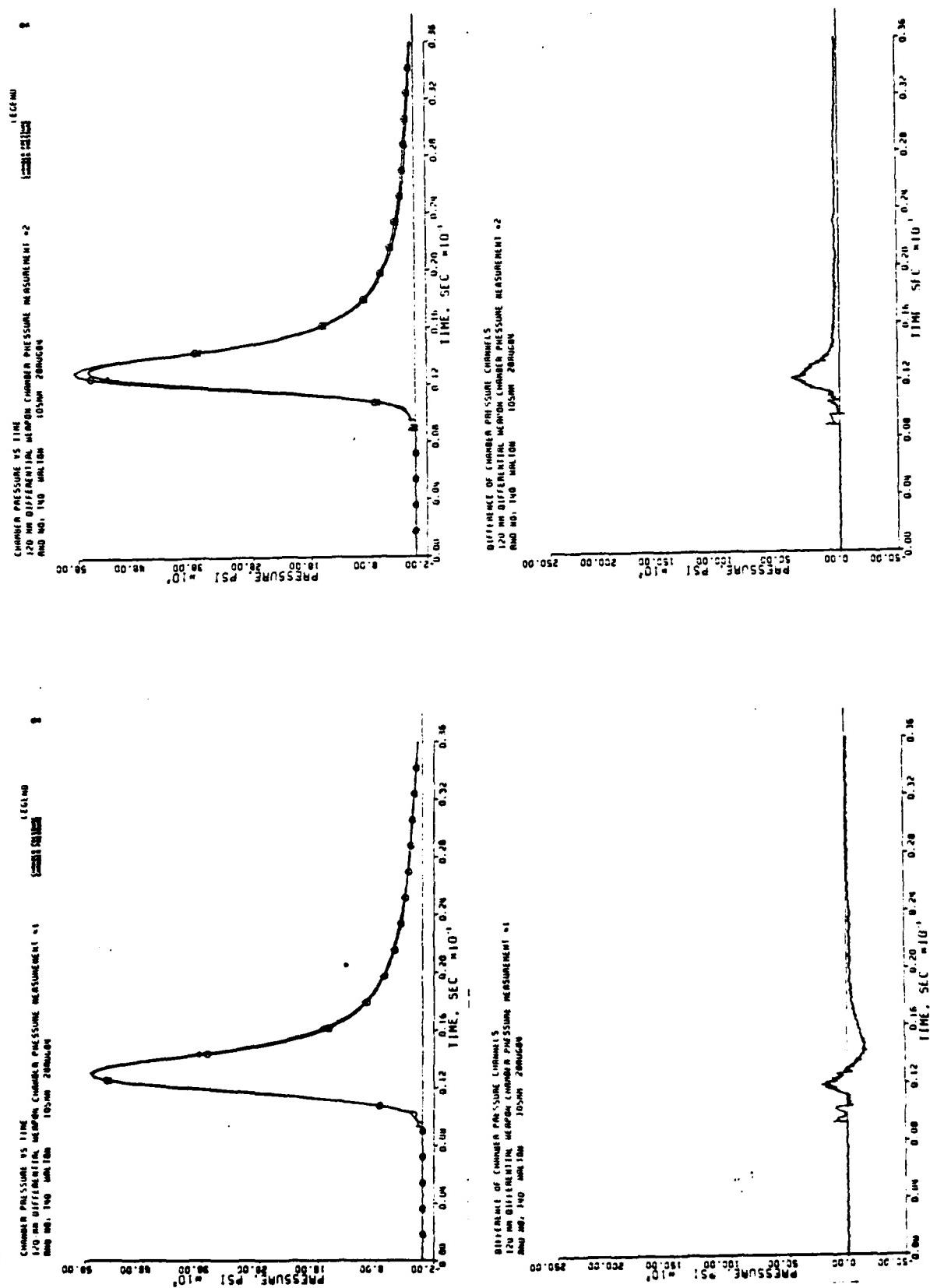


Figure 2.5-2a. Round No. T40.

2.5 (Cont'd)

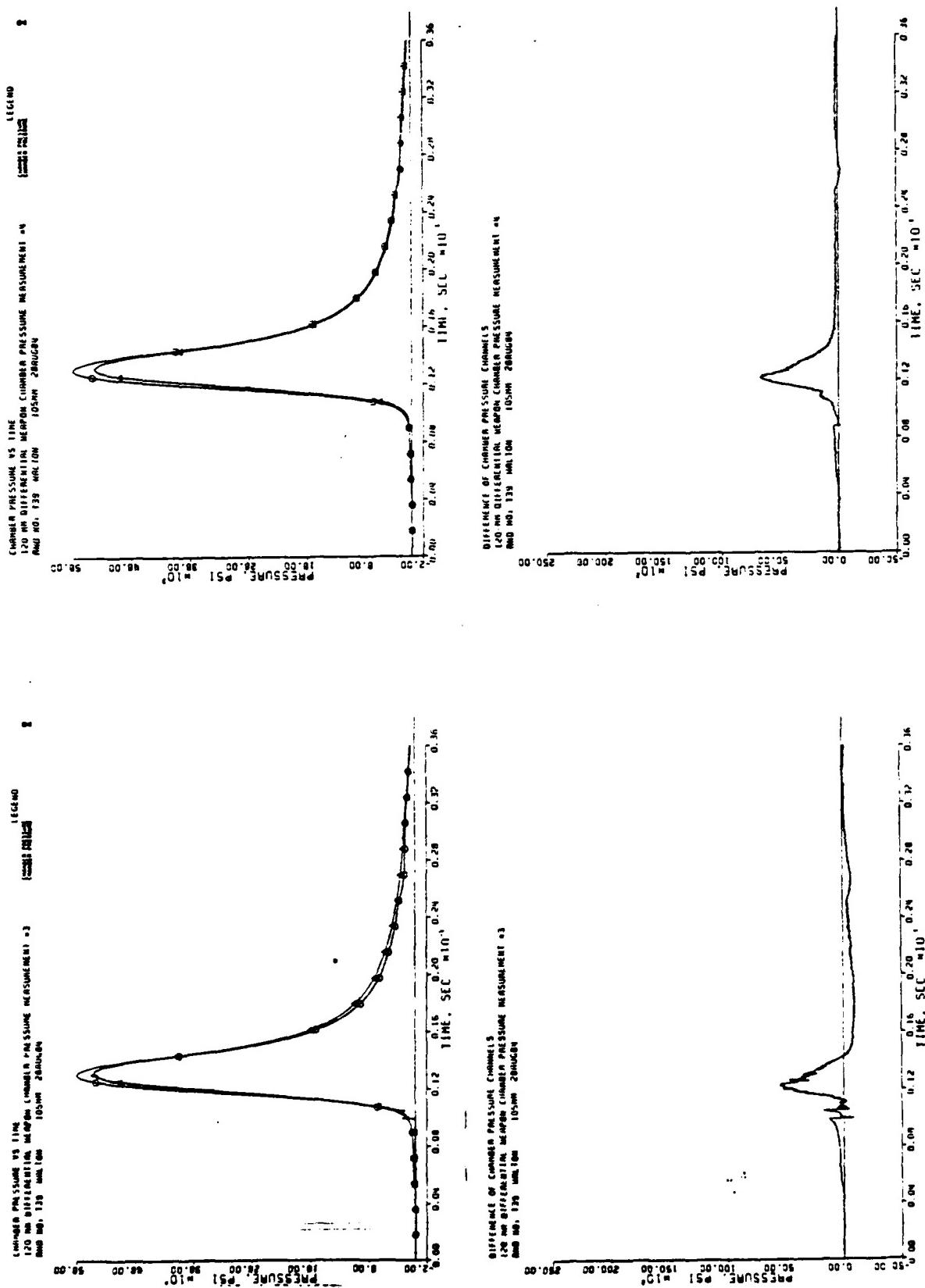


Figure 2.5-1b. Round No. T39.

2.5 (Cont'd)

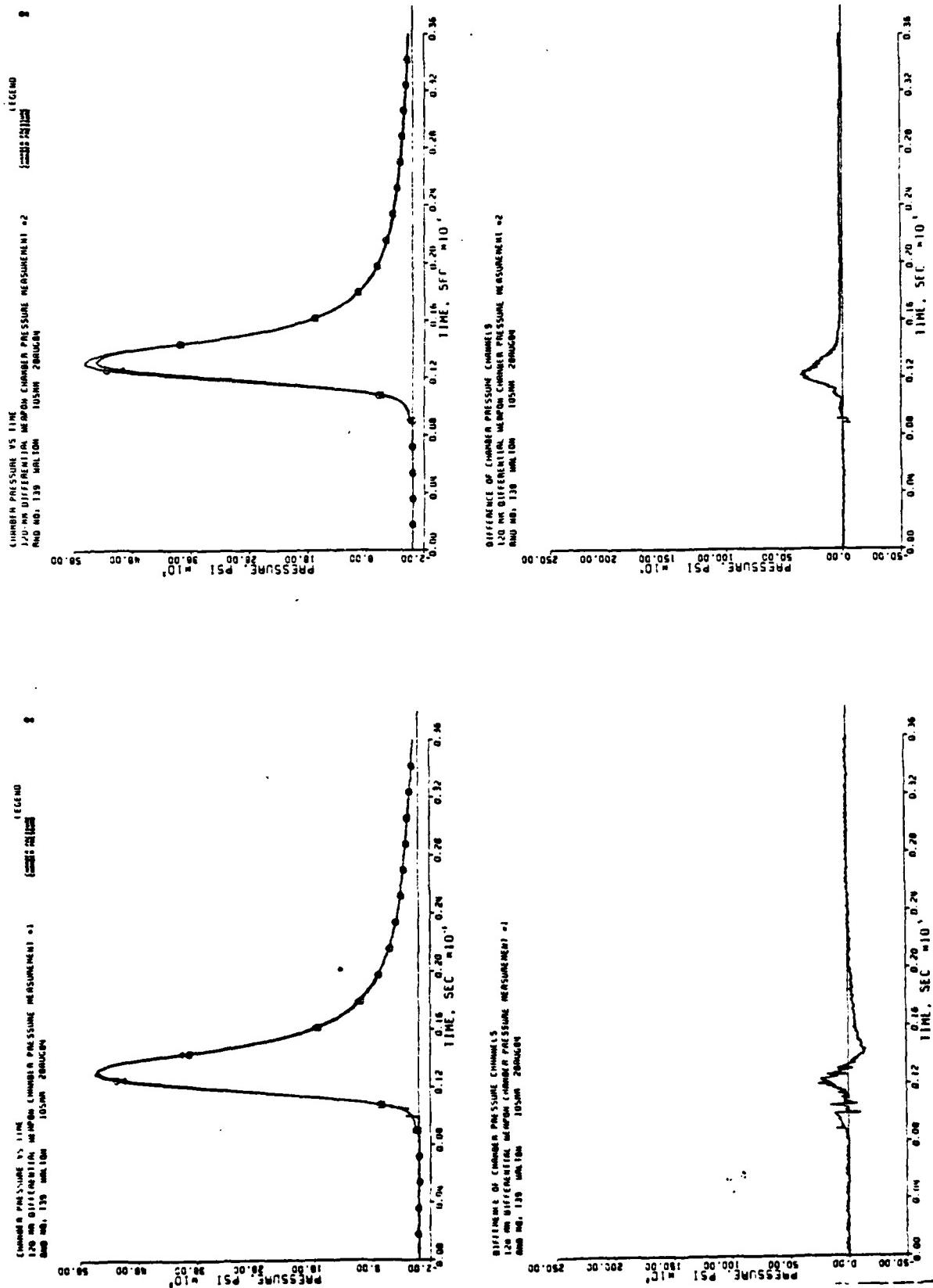
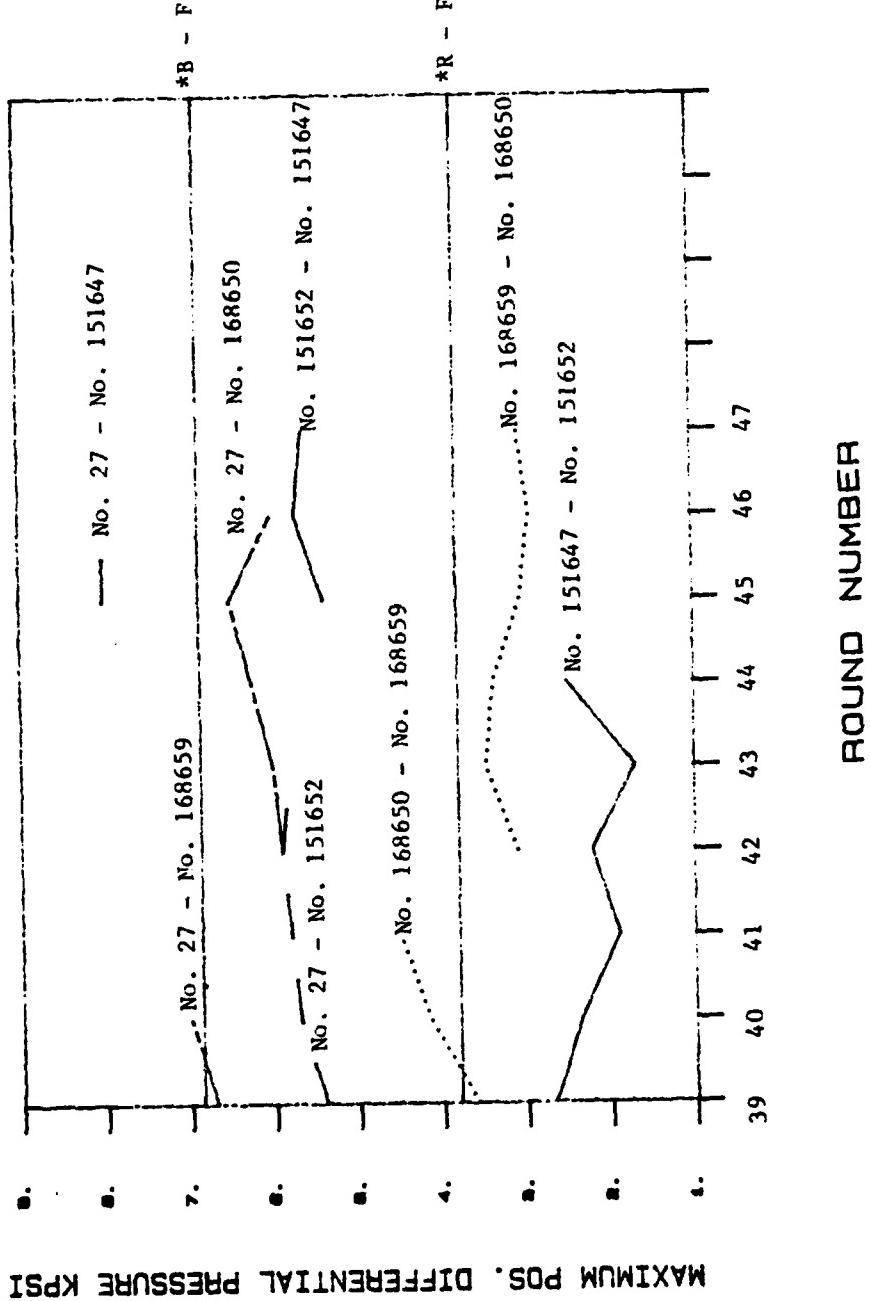


Figure 2.5-1a. Round No. T39.

## MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.  
 B - F = Base minus forward gage.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.5-1(2). Maximum positive differential pressure.

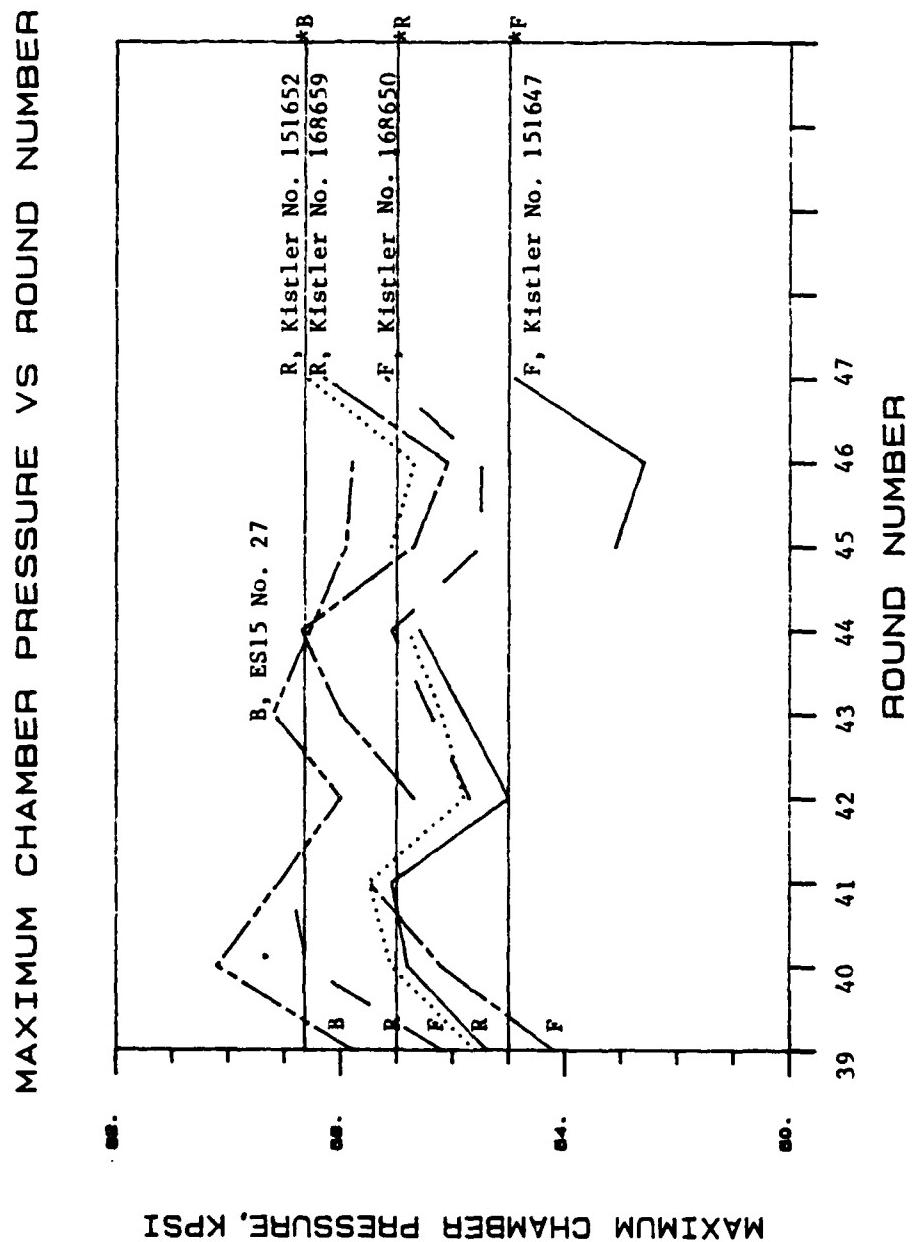


Figure 2.5-1(1). Maximum chamber pressure.

TABLE 2.5-1. CHAMBER PRESSURE DATA - PHASE Ie

105-mm Tank Gun  
 Tube SN 25970  
 Cartridge: M392A2  
 Temperature: +70° F

Rd No.	Ch 1	Amp Position	Ch 2	Amp Position	Ch 3	Amp Position	Ch 4	Amp Position	Ch 5	Amp Position	Maximum Chamber Pressure, kpsi		Maximum Initial +AP, psi		
											Kistler No. 151652 in Adapter No. 3		Kistler No. 151652 in Adapter No. 4		
											Rd No.	Gage	Gage	Rear - Forward Channels 1 or 2	Base - Forward Channels 1 or 2
<b>Date Fired: 28 August 1984</b>															
T39	455.4	316	Rear	455.6	316	Forward	56.2	316	Rear	56.2	316	Forward	57.8	316	Base
T40	456.8	316	Rear	457.1	316	Forward	58.6	316	Rear	58.2	316	Forward	60.2	316	Base
<b>Date Fired: 29 August 1984</b>															
T41	457.1	316	Rear	457.5	316	Forward	58.9	316	Rear	57.5	316	Forward	NR	316	—
T42	455.0	316	Rear	455.8	316	Forward	55.7	316	Forward	56.7	316	Forward	58.0	316	Base
T43	455.8	316	Rear	456.2	316	Forward	56.4	316	Forward	58.0	316	Forward	59.2	316	Base
T44	456.6	316	Rear	456.8	316	Forward	57.1	316	Forward	58.7	316	Forward	NR	316	—
T45	53.1	316	Forward	57.1	316	Rear	55.5	316	Forward	56.7	316	Rear	57.9	316	Base
T46	52.6	316	Forward	56.7	316	Rear	55.5	316	Forward	56.1	316	Rear	57.8	316	Base
T47	54.9	316	Forward	58.6	316	Rear	57.2	316	Forward	58.3	316	Rear	NR	316	—

\*Forward peak pressure greater than rear peak pressure, oscillation occurs at peak pressure.

NA = Not applicable.

NR = Not recorded.

Ch = Channel.

2.5 (Cont'd)

The calibration records for gages 151647 and 151642 in Appendix B show that the gages are within 1% error to 15,000 psi, but under 15,000 psi, the percentage linearity is poor. This is not an unusual performance for pressure gage calibrations. The calibration data alone does not provide a complete indicator of performance under firing conditions. Linearization of the calibration record is covered in more detail in paragraph 2.10 of this report.

2.5 (Cont'd)

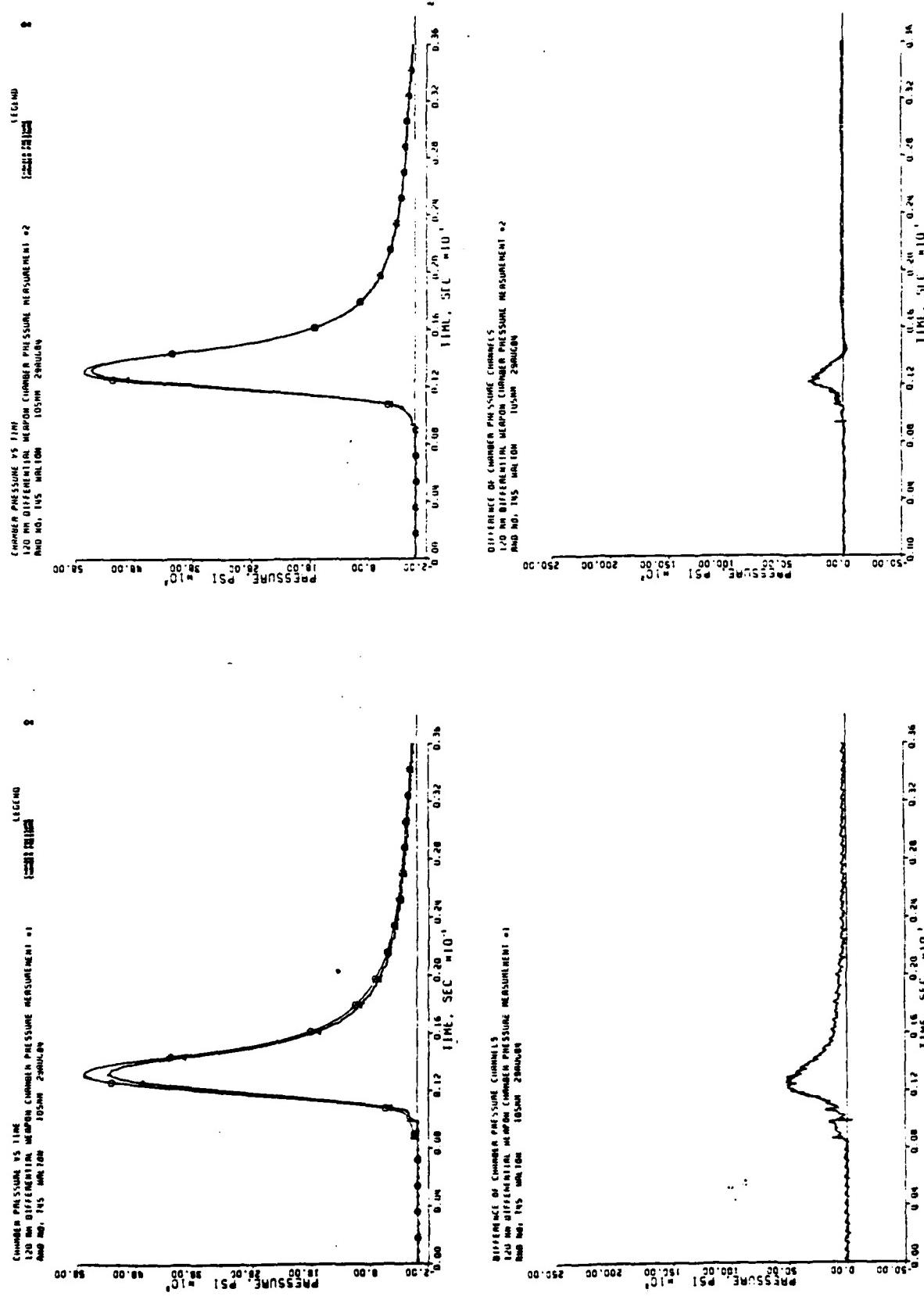


Figure 2.5-7a. Round No. T45.

2.5 (Cont'd)

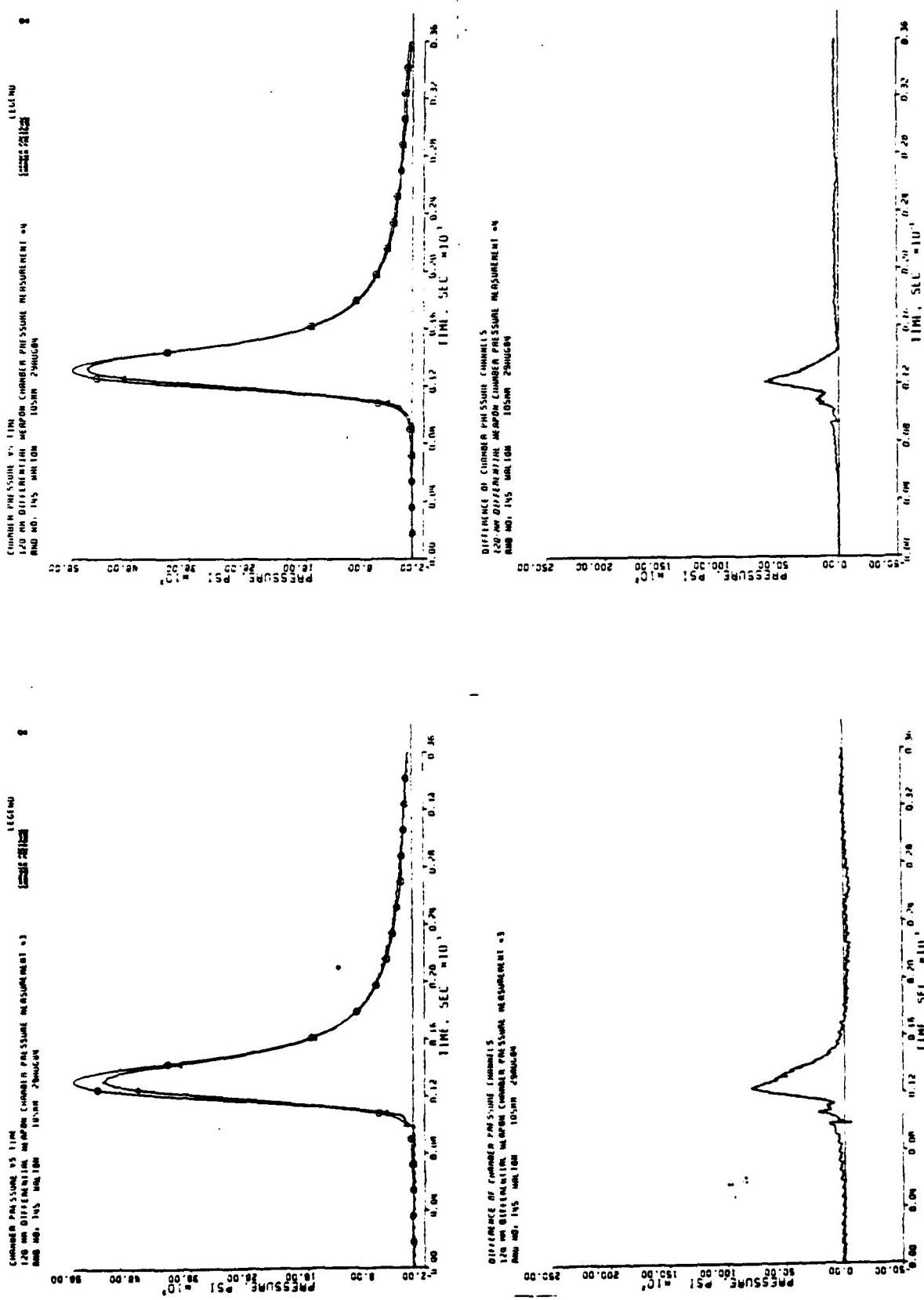


Figure 2.5-7b. Round No. T45.

2.5 (Cont'd)

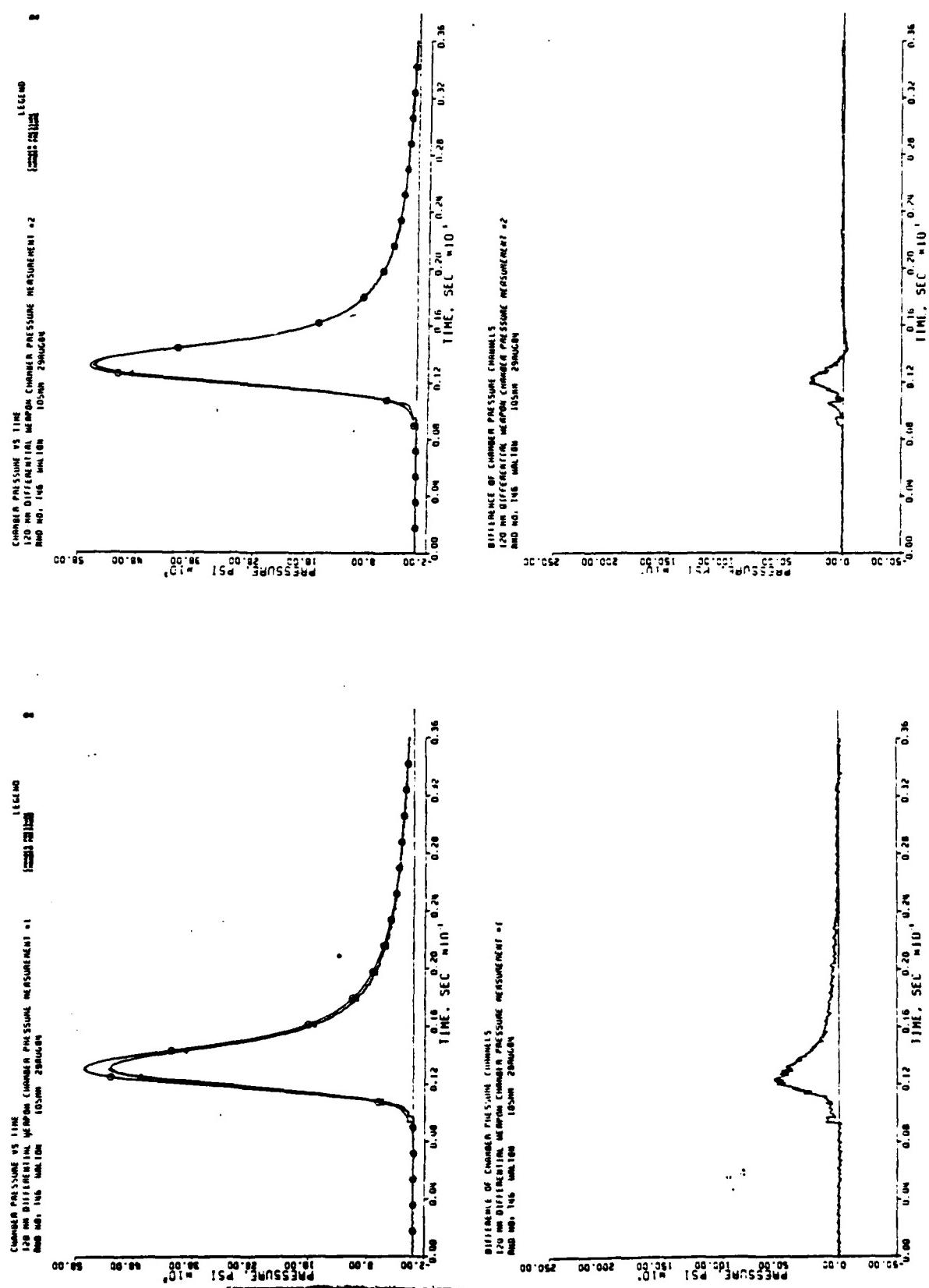


Figure 2.5-8a. Round No. T46.

2.5 (Cont'd)

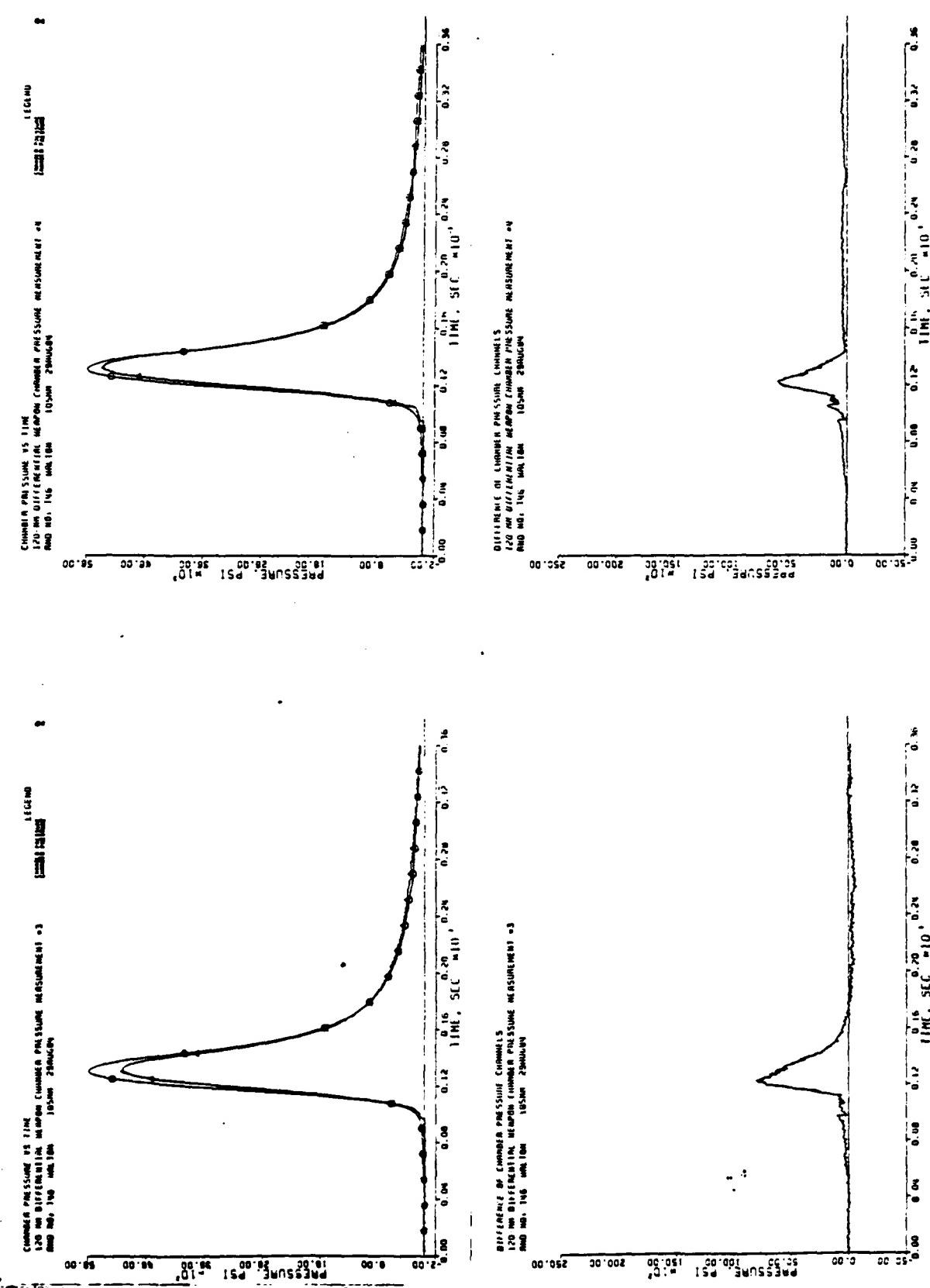


Figure 2.5-8b. Round No. T46.

2.5 (Cont'd)

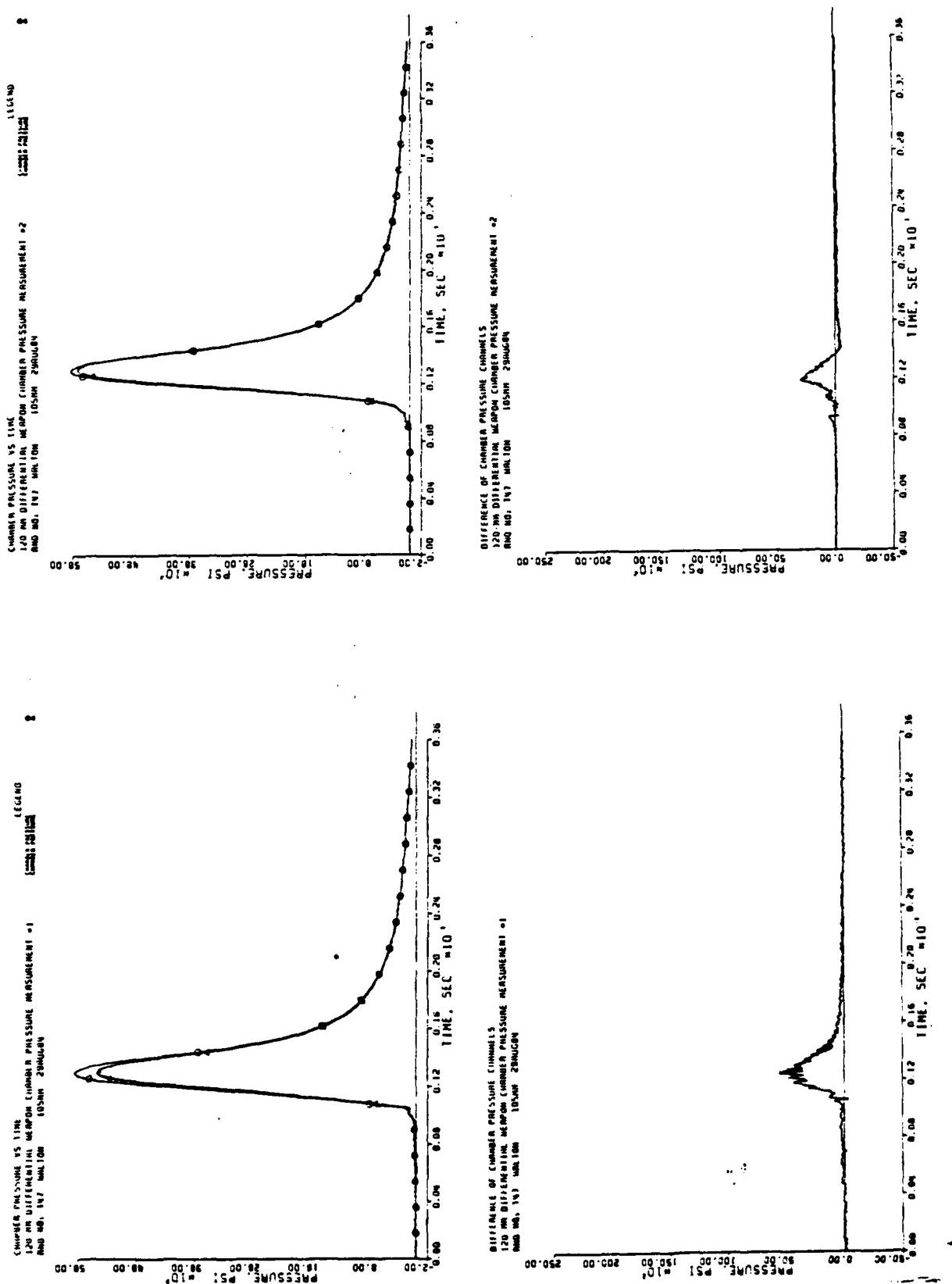


Figure 2.5-9. Round No. 747.

## 2.6 PHASE If. ROUNDS 48 THROUGH 60, TUBE 25970

Kistler 6211 gage No. 168653 in adapter No. 13 was mounted in the rear position, and Kistler 6211 No. 168658 in adapter No. 14 was mounted in the forward position on the right side of the tube. These gages had no history of performance on firing programs. The test phase was started with the 316 charge amplifier, and was changed to the Kistler 504 toward the end of the test phase. Kistler gages No. 151650 and 151653 were positioned in the left side of the tube in the rear and forward positions. Charge amplifiers were changed from the 316 to the 504 toward the end of the phase. An attempt was made to check the effect of heat on this pair of gages by intentionally not greasing for two consecutive shots.

The performance of the gages on the right side was acceptable throughout the phase. A higher incidence of noise and slight variations in return to zero on the differential plots occur after gage positions were changed at round 54. Peak differential pressures drop slightly at round 54 for the rear - forward combination, but not of a sufficient amount to disqualify the performance of a particular gage. The base - forward pressures are typical, and the peak pressures are within the expected range. Changing charge amplifiers does not have a discernible effect on either the peak differential pressure or on the shape of the pressure waveforms.

The left set of gages are an excellent example of gage sensitivity to position. The phase begins with 151650 in the rear, and 151653 in the front position. Three shots are fired with reasonable peak pressures, differential peak pressures, and satisfactory returns to zero baseline on the differential plots. When the gage positions are reversed after round 50, a large positive offset is evident on the differential return to zero. The positive offset remains evident throughout the remainder of the phase, and does not change appreciably when the gages are not greased. Not only is there no change in the shape of the rear - forward differential plot, but the peak pressures do not appear affected. From these limited results, defective performance of gages due to heat effects may not be as frequently encountered as previously thought.

Several factors combine to produce the performance evident for rounds 51 through 60. First, the forward gage is reading consistently low, at approximately 53.5 Kpsi. Second, the rear gage contributes to the long duration of the positive offset on the rear - forward differential plots. Finally, the forward gage contributes to an offset of approximately 10 milliseconds duration. Various combinations of charge amplifier models have no obvious effect on performance.

If a file was maintained on the performance of gages 151650 and 151653, it is likely that both would be looked upon with suspicion for future firing programs. Given the demands of current firing schedules and the importance of good pressure records, the selection of another set of gages is the most cost effective alternative.

105-mm Tank Gun  
Tube SN 25970  
Cartridge: M392A2  
Temperature: +70° F

TABLE 2.6-1. CHAMBER PRESSURE DATA - PHASE II

Ed No.	Ch 1	Amp Position	Ch 2	Amp Position	Ch 3	Amp Position	Ch 4	Amp Position	Ch 5	Amp Position	Gage	Position	Maximum Chamber Pressure, Kpsi		Initial +ΔP, psi		Base - Forward		Rear - Forward		Base - Forward			
													Kistler No. 151650		Kistler No. 151653		Channels 1 or 2		Channels 3 or 4		Channels 1 and 2		Channels 3 and 4	
													Gage	Position	Gage	Position	NR	NR	NR	NR	NR	NR	NR	NR
Date Fired: 30 August 1984																								
T48	57.9	316	Rear	55.4	316	Forward	58.7	316	Rear	55.6	316	Forward	59.4	316	Base	4060	3600	6700	6600	3610	6500	6000	6000	
T49	56.5	316	Rear	56.4	316	Forward	56.8	316	Rear	55.1	316	Forward	57.8	316	Base	4040	3610	6500	6000	3240	MA	MA	MA	
T50	58.0	316	Rear	55.8	316	Forward	58.4	316	Rear	56.4	316	Forward	58.6	316	Base	4070	316	-	4070	3240	MA	MA	MA	
T51	57.3	316	Rear	55.1	316	Forward	53.8	316	Forward	56.9	316	Rear	58.6	316	Base	4060	4840	6600	6600	4840	6600	7500	7500	
T52	56.1	316	Rear	53.8	316	Forward	53.2	316	Forward	56.1	316	Rear	57.3	316	Base	4180	4590	6300	6300	4180	6300	7100	7100	
T53	58.2	316	Rear	55.9	316	Forward	55.1	316	Forward	57.8	316	Rear	57.8	316	Base	4110	4800	MA	MA	4110	4800	4400	4400	
T54	54.6	316	Forward	56.0	316	Rear	55.1	316	Forward	55.6	316	Rear	57.7	316	Base	3680	4290	6400	6400	3680	4290	7400	7400	
T55	55.5	316	Forward	57.3	316	Rear	53.4	316	Forward	56.7	316	Rear	58.7	316	Base	3620	4640	6100	6100	3620	4640	6100	6100	
T56	56.8	316	Forward	58.1	316	Rear	53.8	316	Forward	57.7	316	Rear	59.6	316	Base	3260	5560	MA	MA	3260	5560	6100	6100	
T57	56.0	304	Forward	57.3	316	Rear	53.4	504	Forward	56.9	316	Rear	58.6	316	Base	3370	4610	6100	6100	3370	4610	7500	7500	
T58	55.6	304	Forward	57.1	316	Rear	53.7	504	Forward	56.7	316	Rear	58.7	316	Base	3100	5280	6100	6100	3100	5280	8500	8500	
Date Fired: 31 August 1984																								
T59	54.5	316	Forward	56.9	504	Rear	53.6	316	Forward	56.1	504	Rear	58.1	316	Base	3520	4520	6500	6500	4440	5440	6200	6200	
T60	55.2	316	Forward	58.2	504	Rear	52.9	316	Forward	56.9	504	Rear	58.7	316	Base	4440	5440	6200	6200	4440	5440	6100	6100	

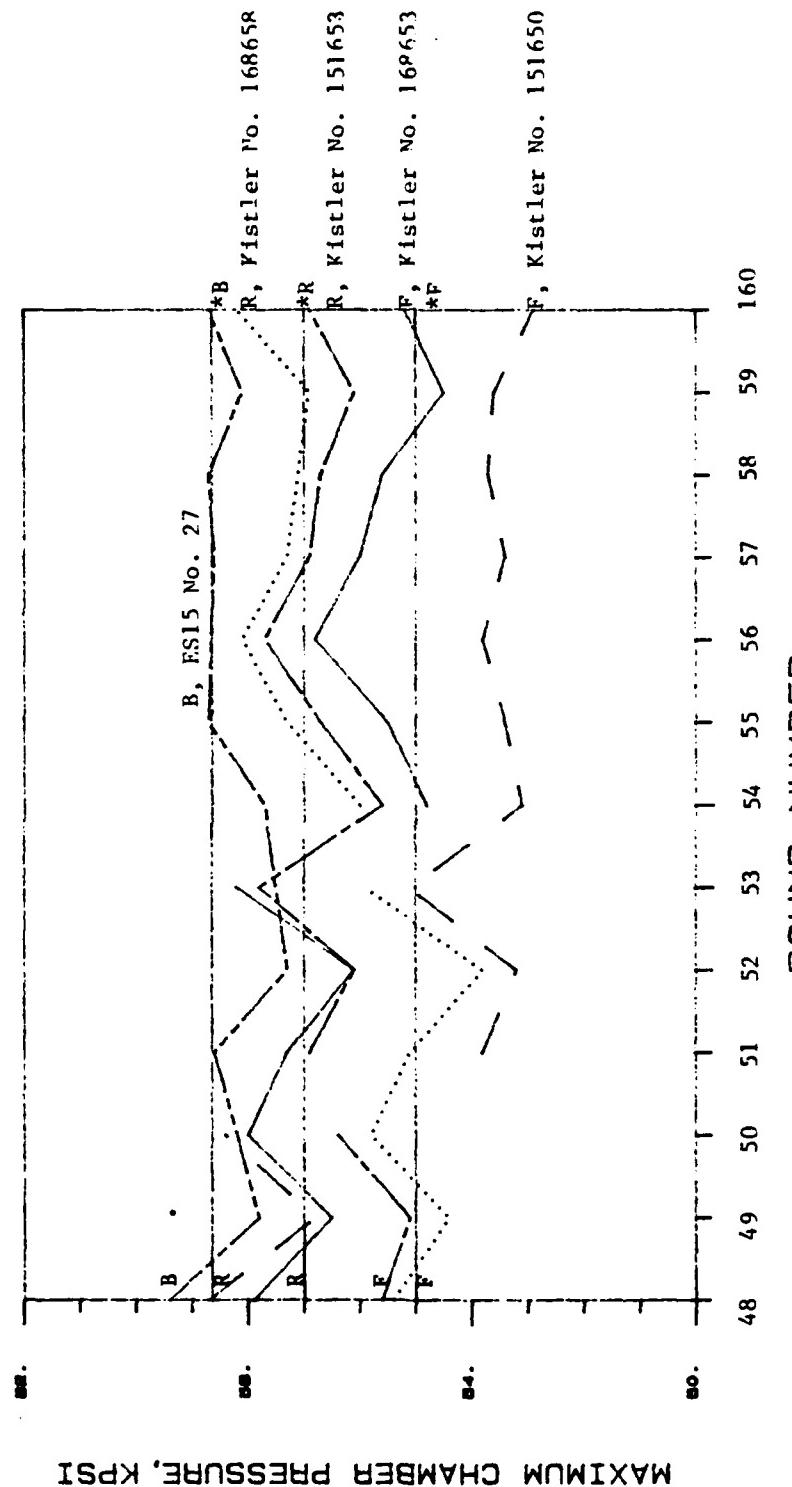
\*No grease applied to gage.

NA = Not applicable.

NR = Not recorded.

CH = Channel.

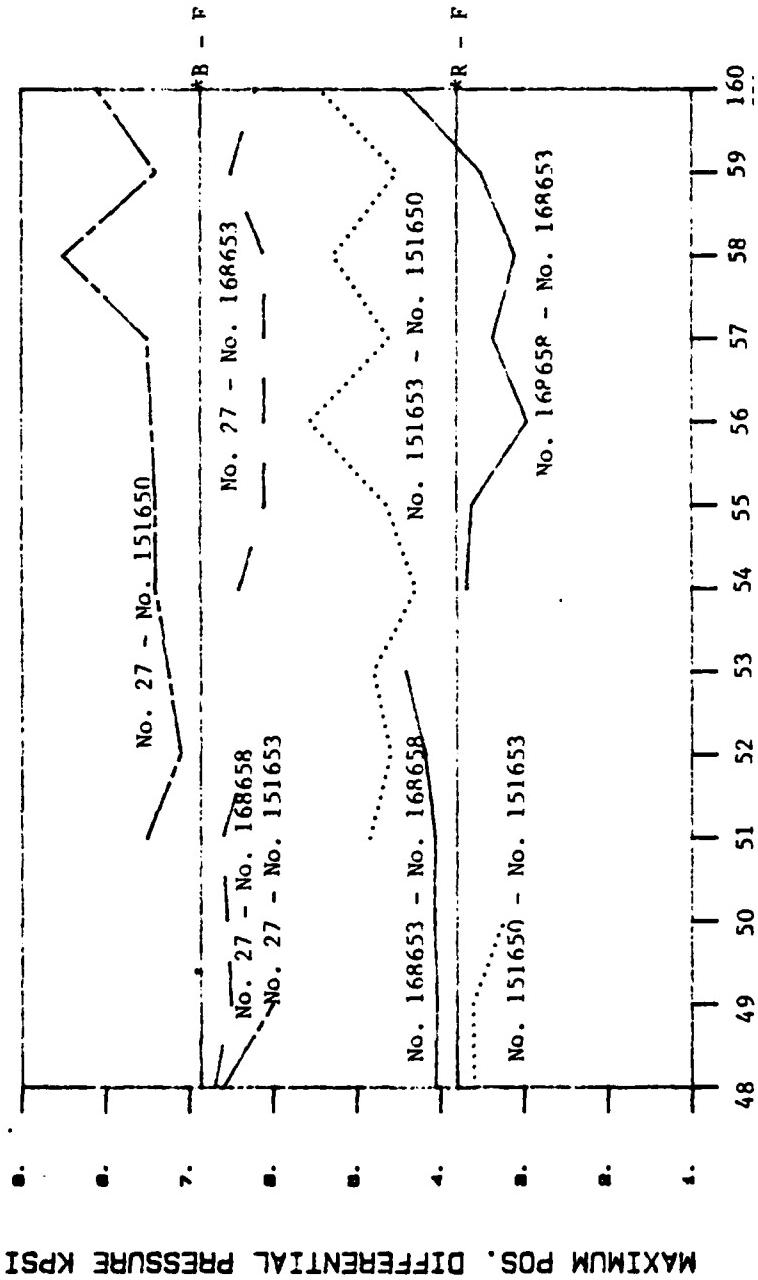
## MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER



F = Forward gage position.  
 R = Rear gage position.  
 B = Base gage position.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.6-1(1). Maximum chamber pressure.

MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.

B - F = Base minus forward gage.

\* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.6-1(2). Maximum positive differential pressure.

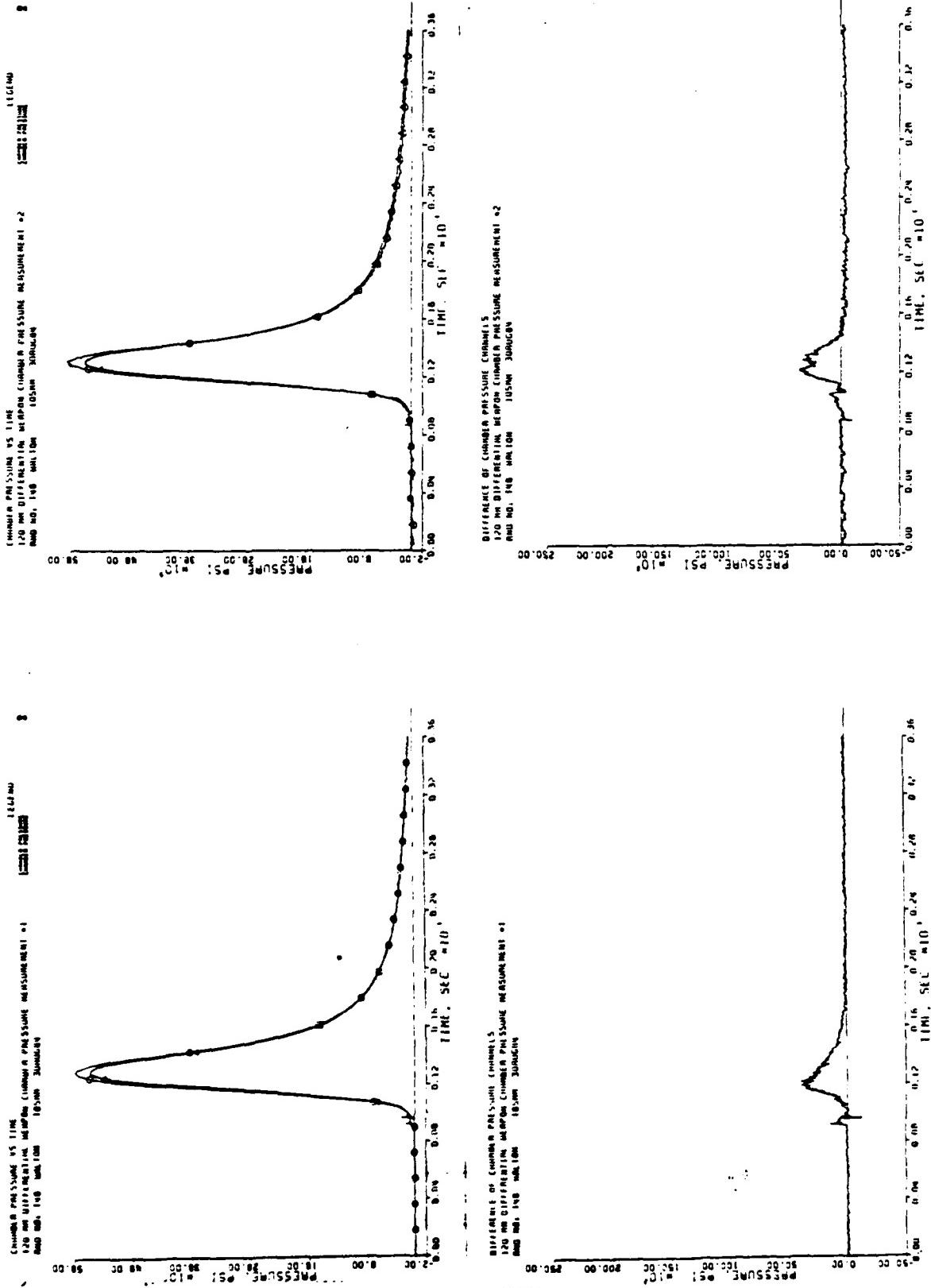


Figure 2.6-1a. Round No. T48.

2.6 (Cont'd)

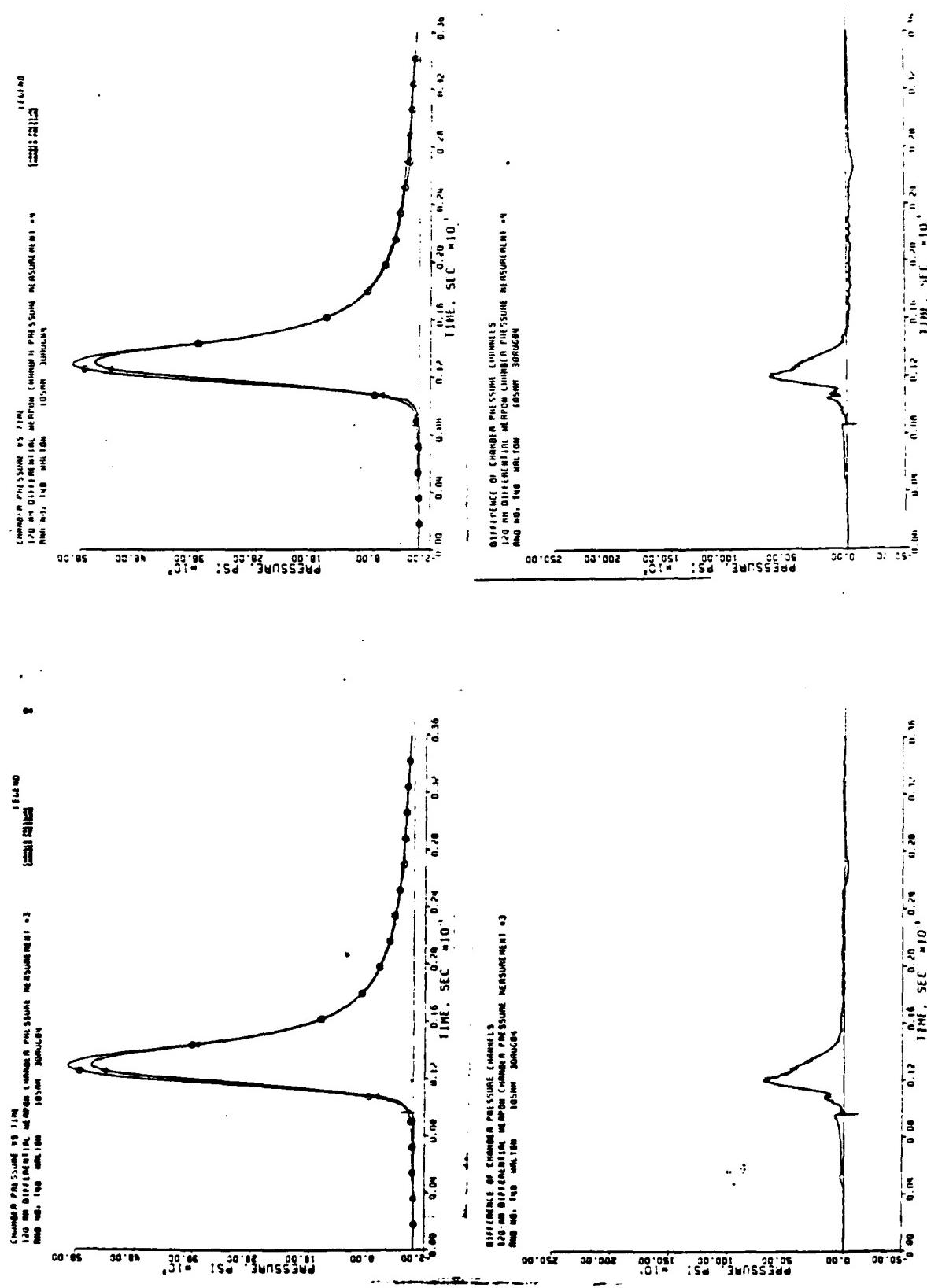


Figure 2.6-1b. Round No. T48.

2.6 (Cont'd)

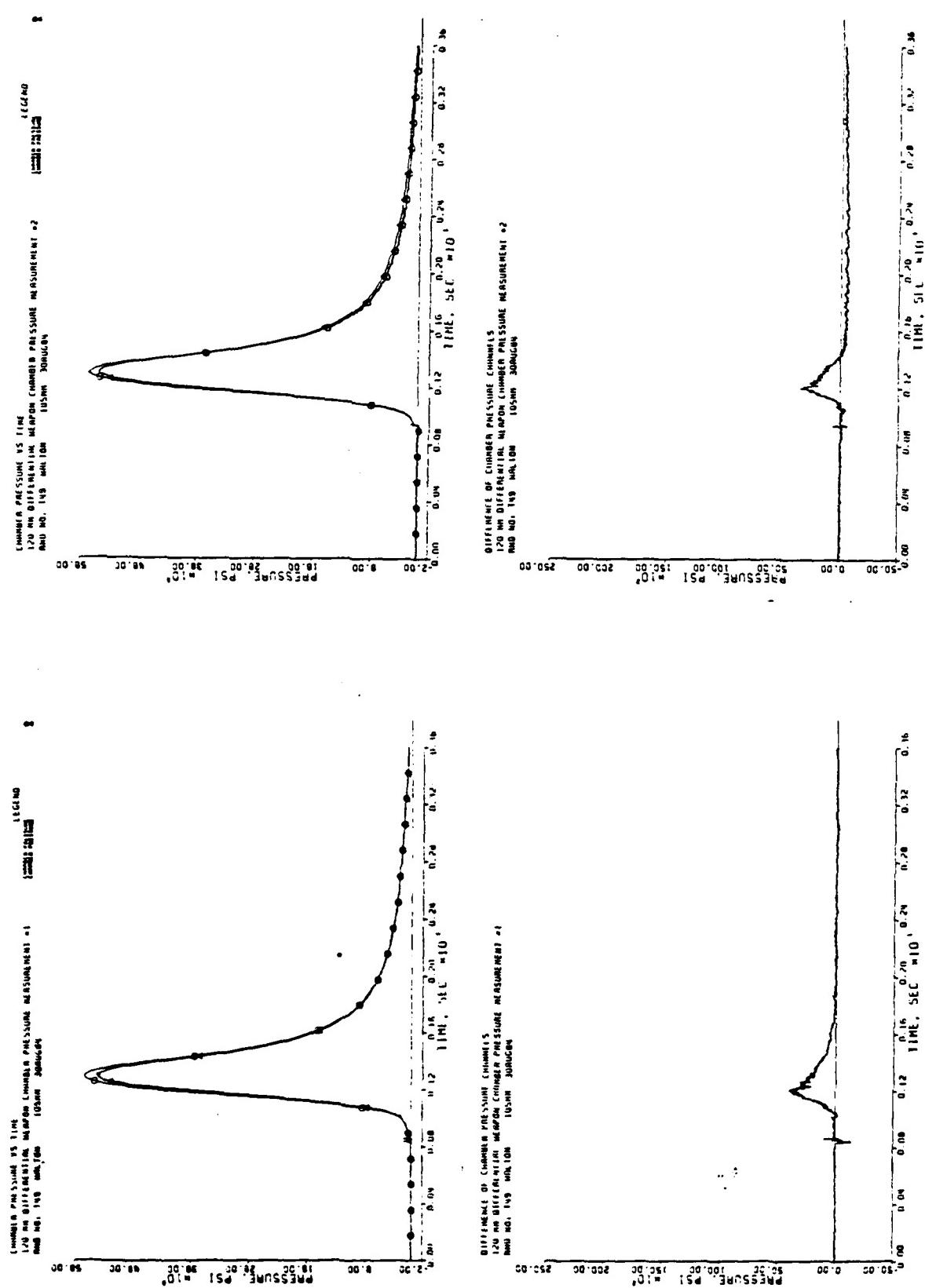


Figure 2.6-2a. Round No. 149.

2.6 (Cont'd)

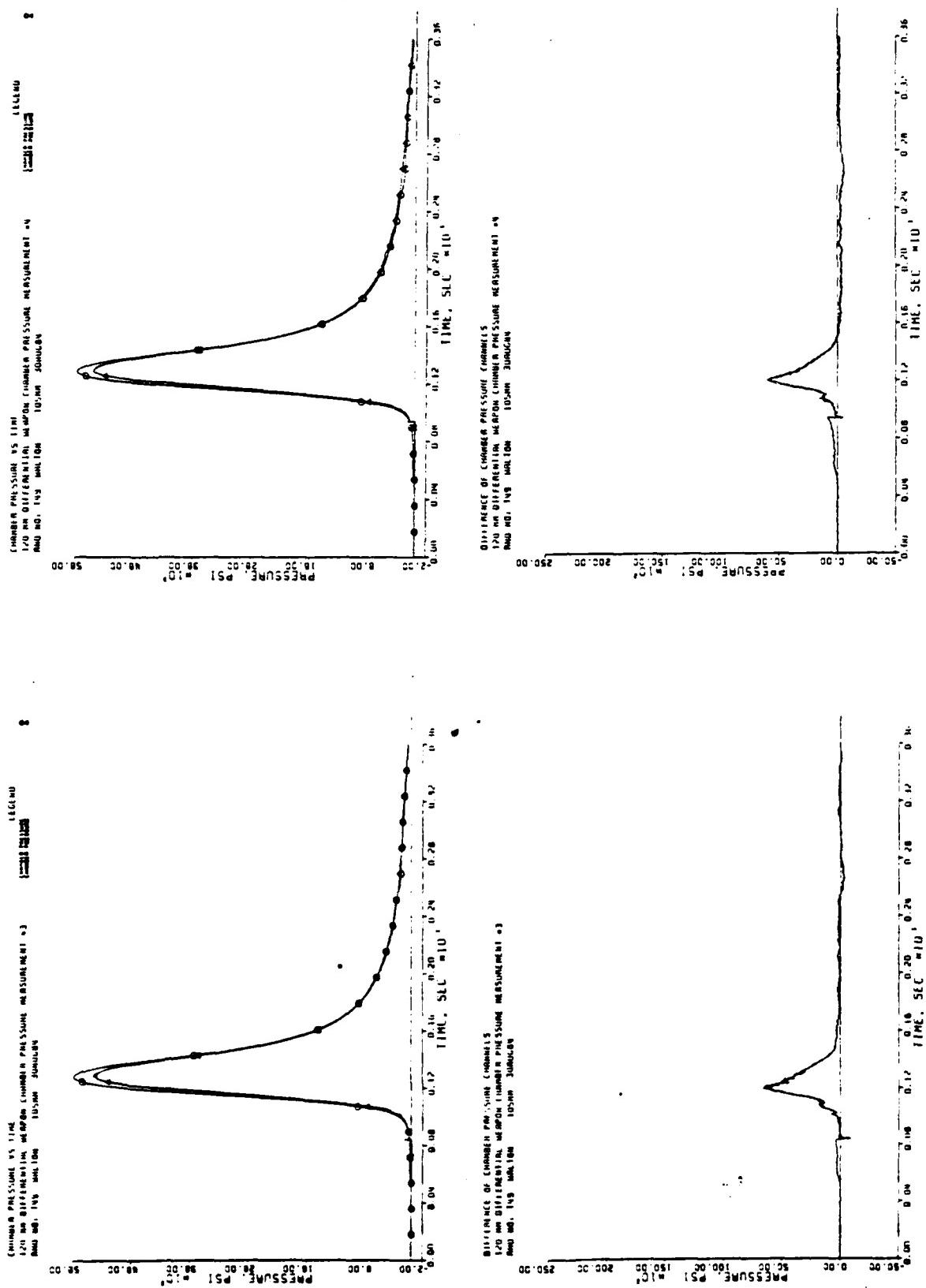


Figure 2.6-2b. Round No. T49.

2.6 (Cont'd)

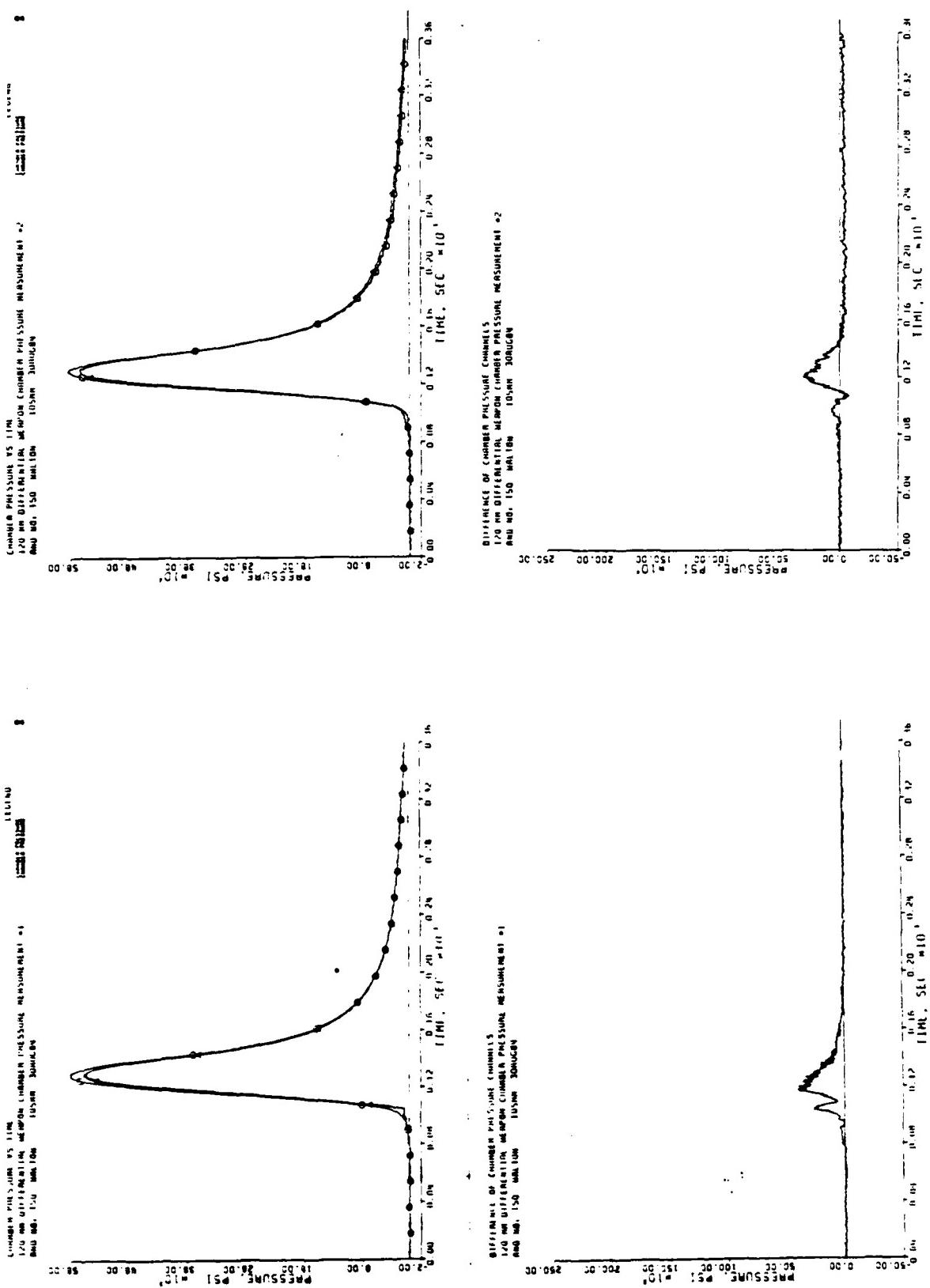
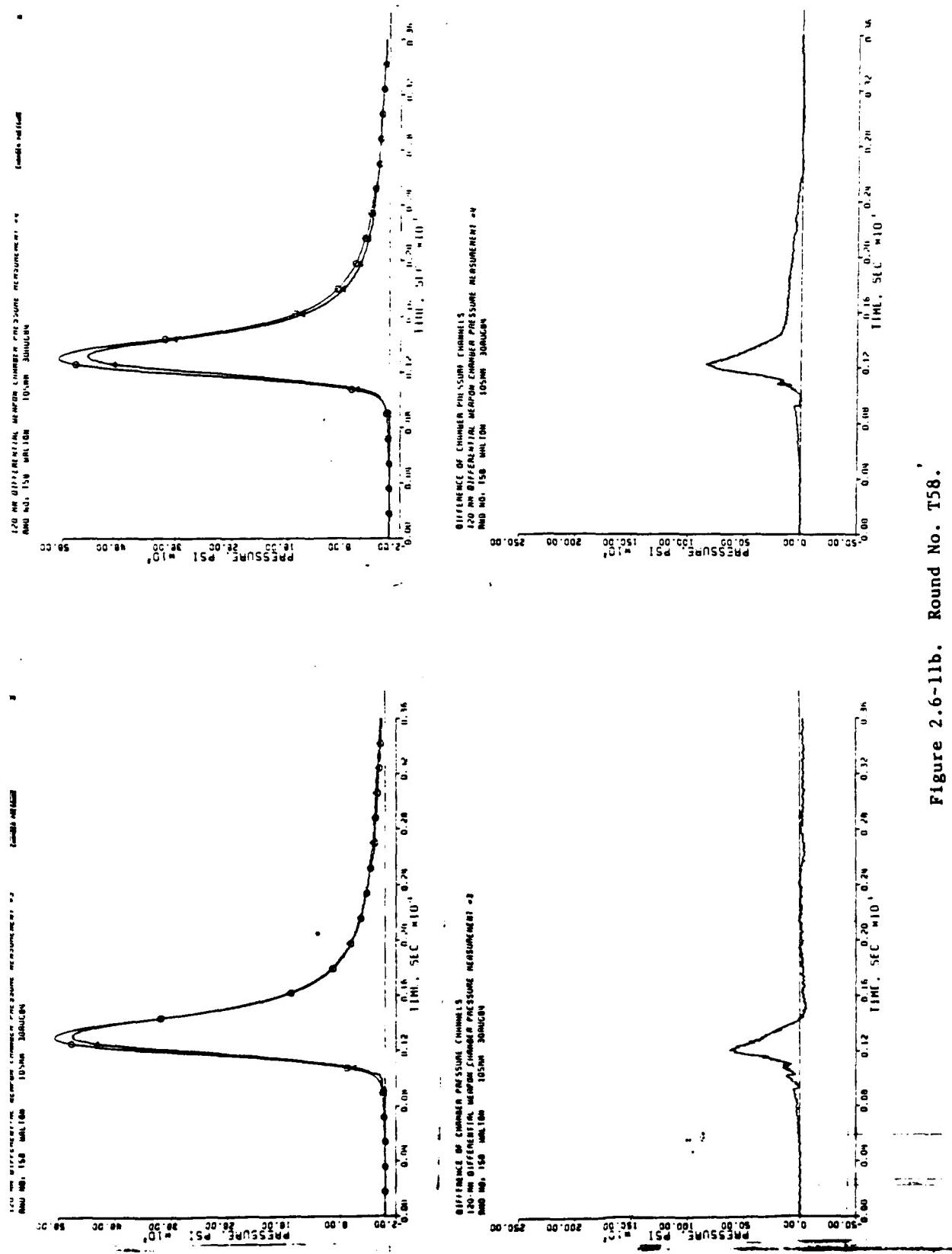


Figure 2.6-3. Round No. T50.

2.6 (Cont'd)



2.6 (Cont'd)

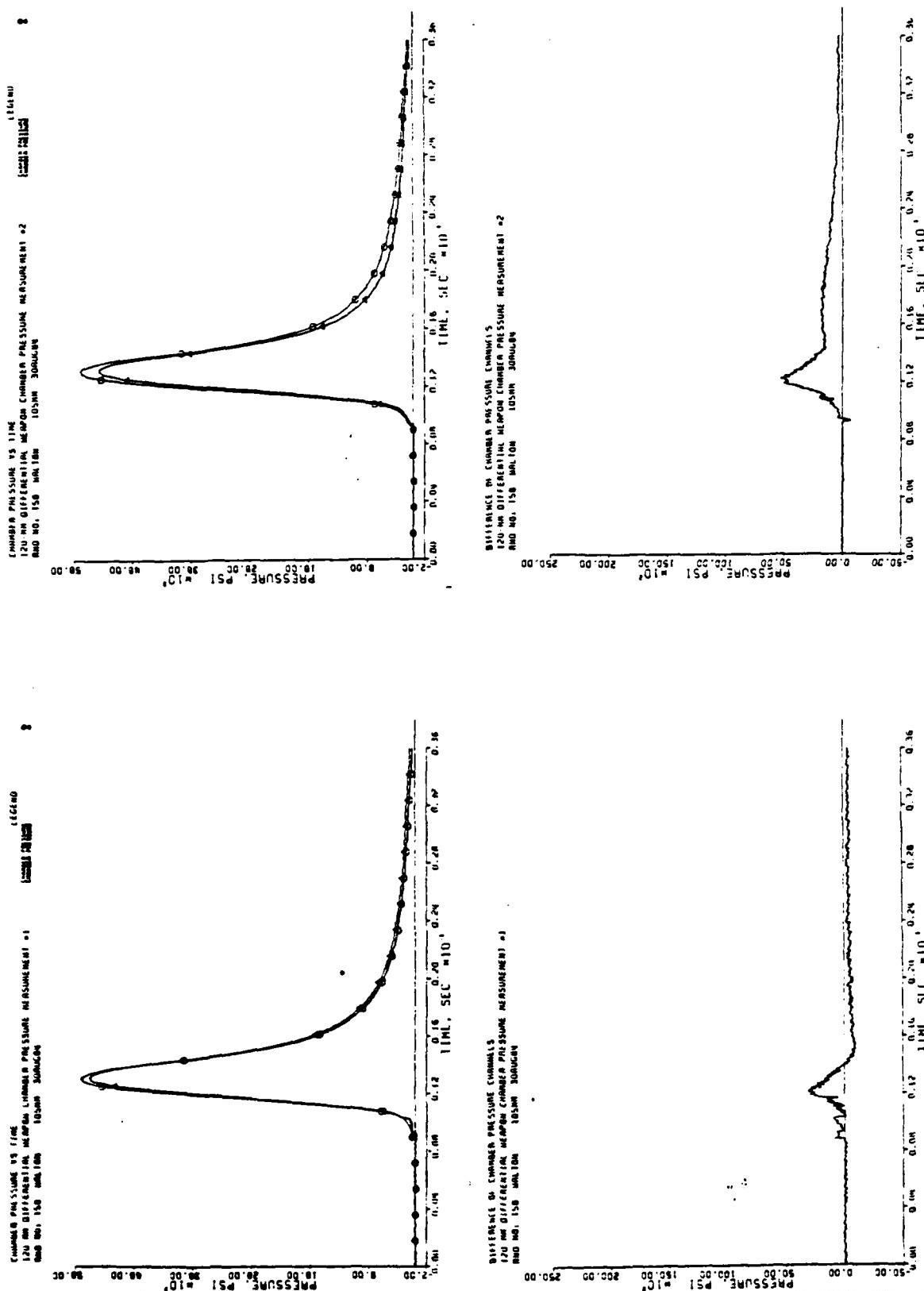


Figure 2.6-11a. Round No. T58.

## 2.6 (Cont'd)

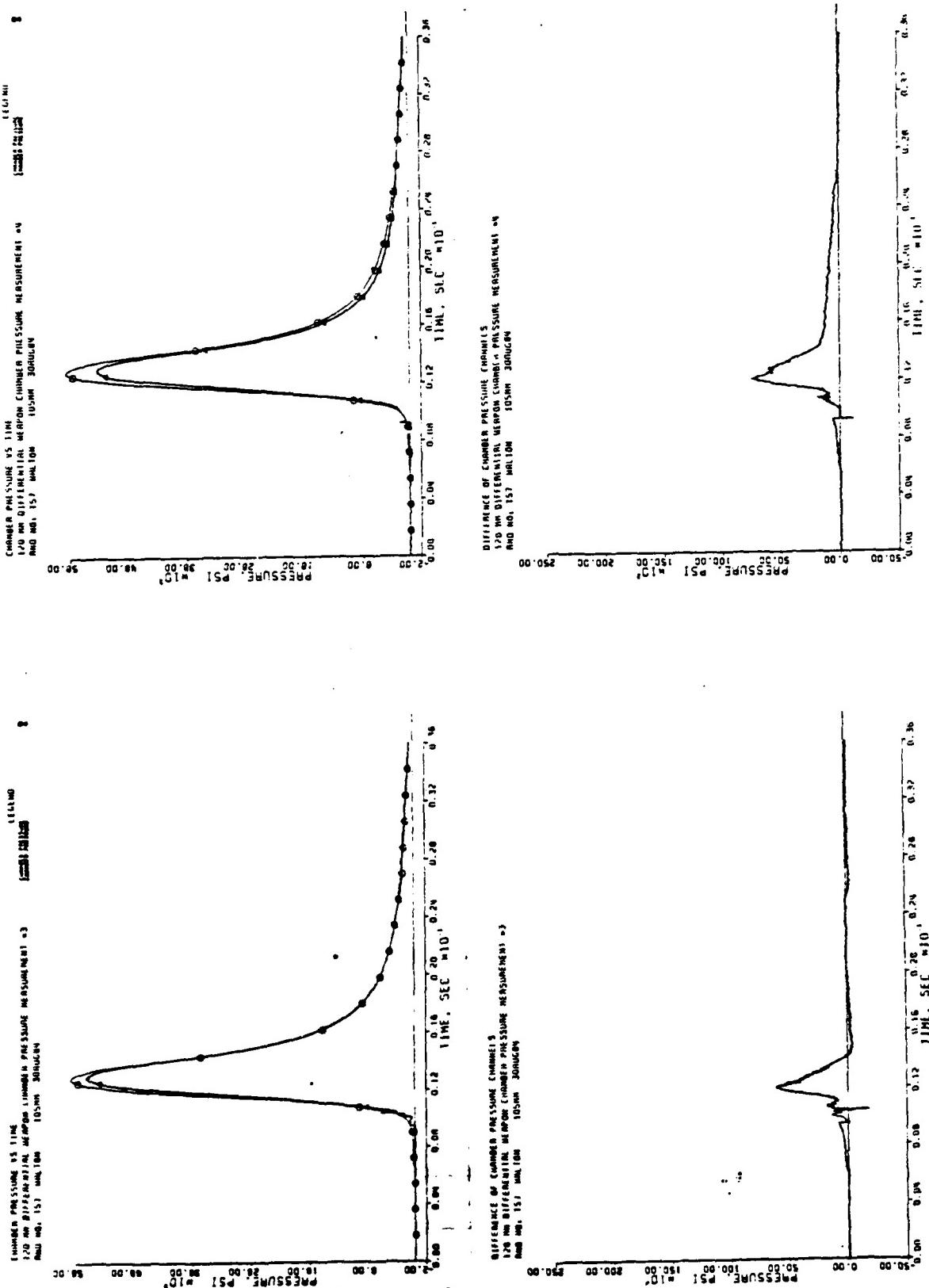


Figure 2.6-10b. Round No. T57.

141a

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2.6 (Cont'd)

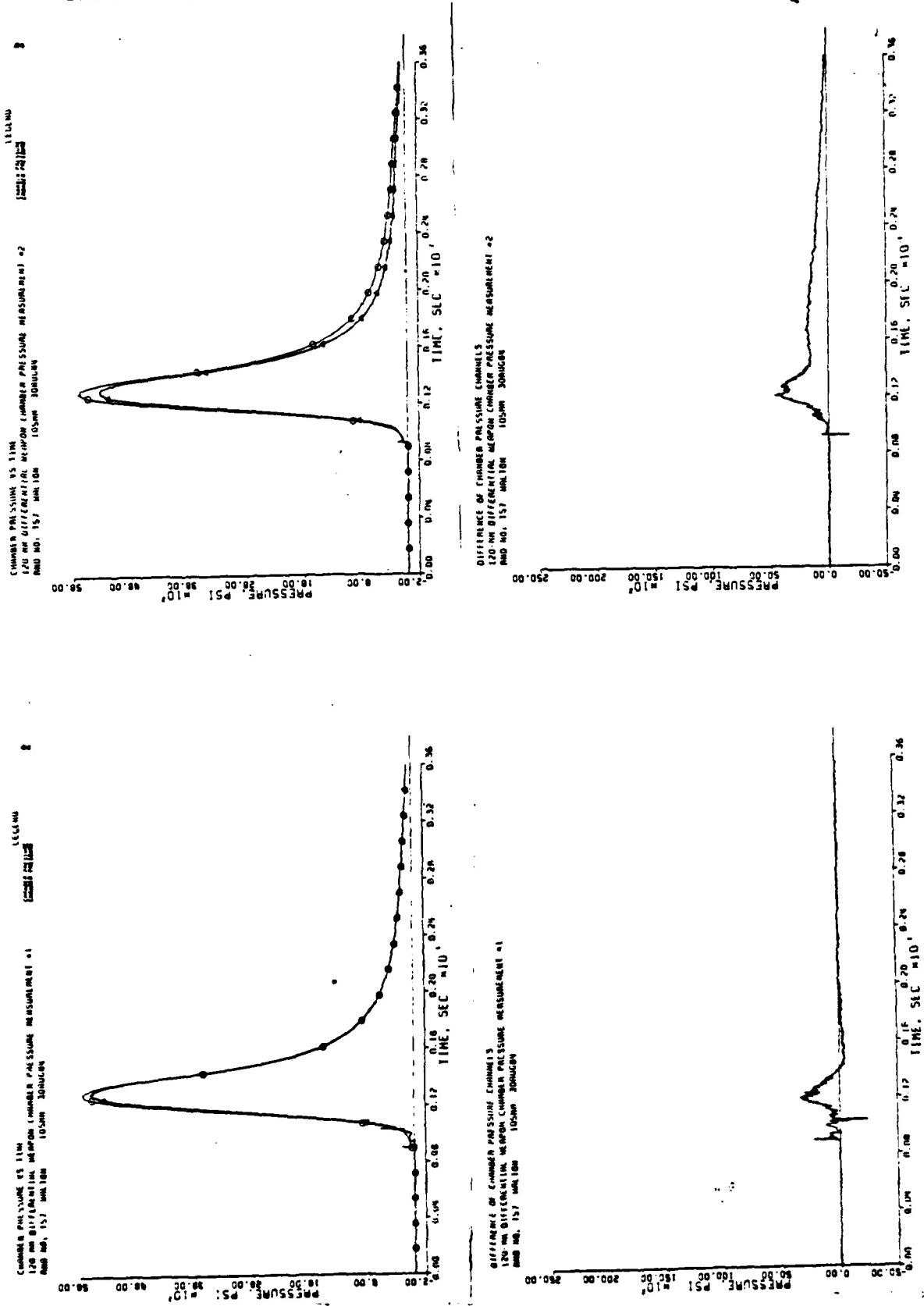


Figure 2.6-10a. Round No. T57.

2.6 (Cont'd)

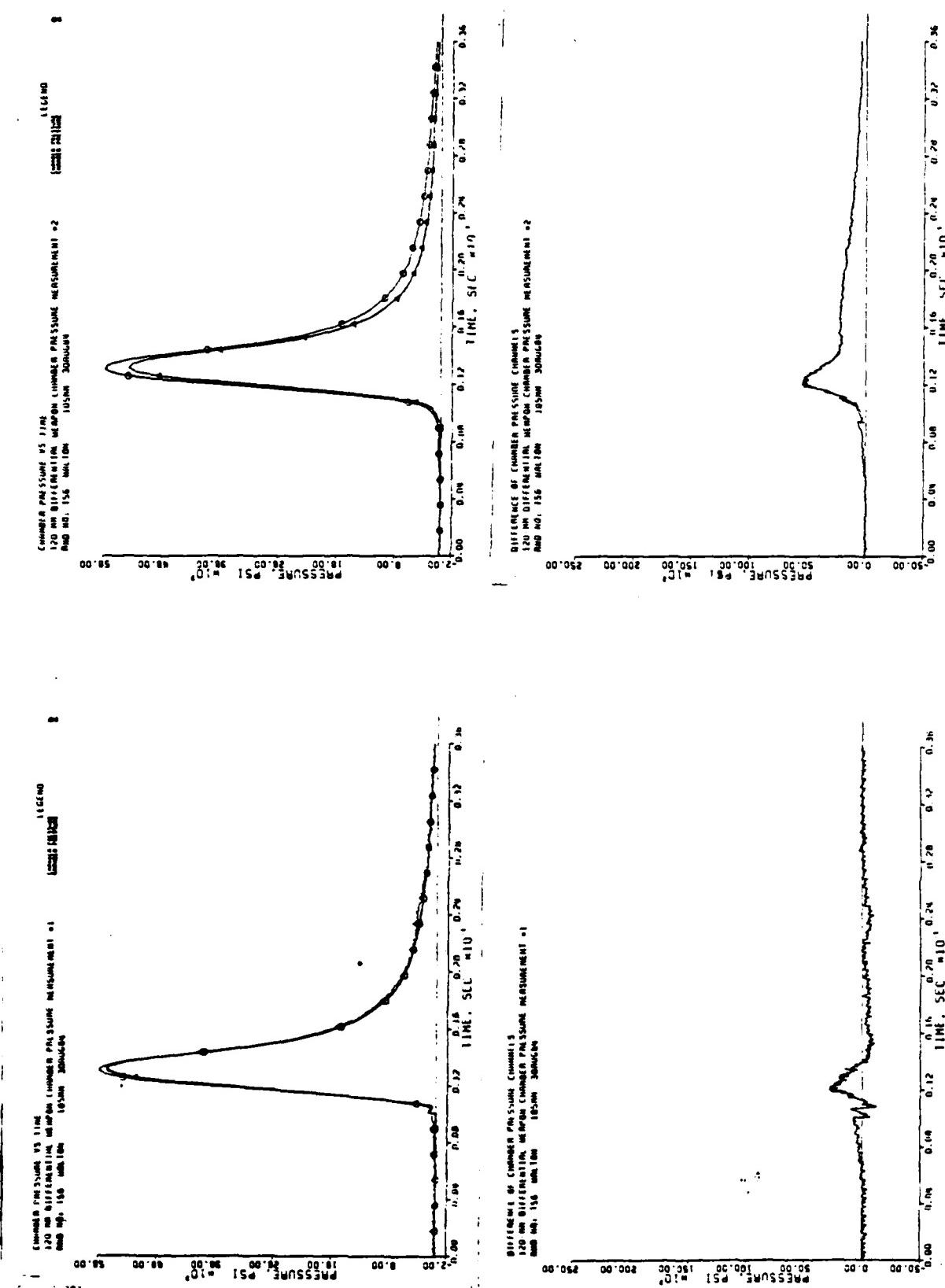


Figure 2.6-9. Round No. T56.

2.6 (Cont'd)

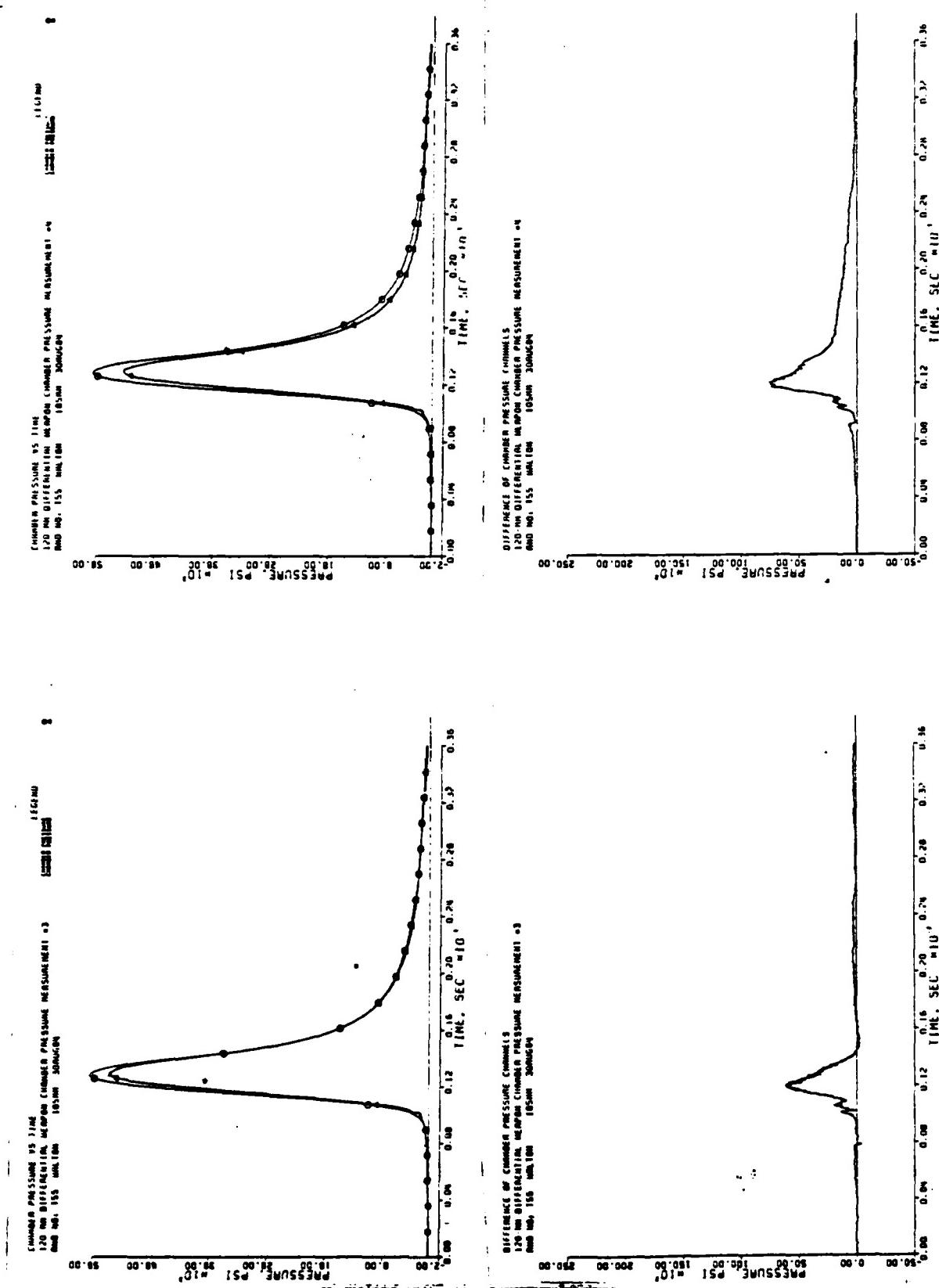


Figure 2.6-8b. Round No. T55.

2.6 (Cont'd)

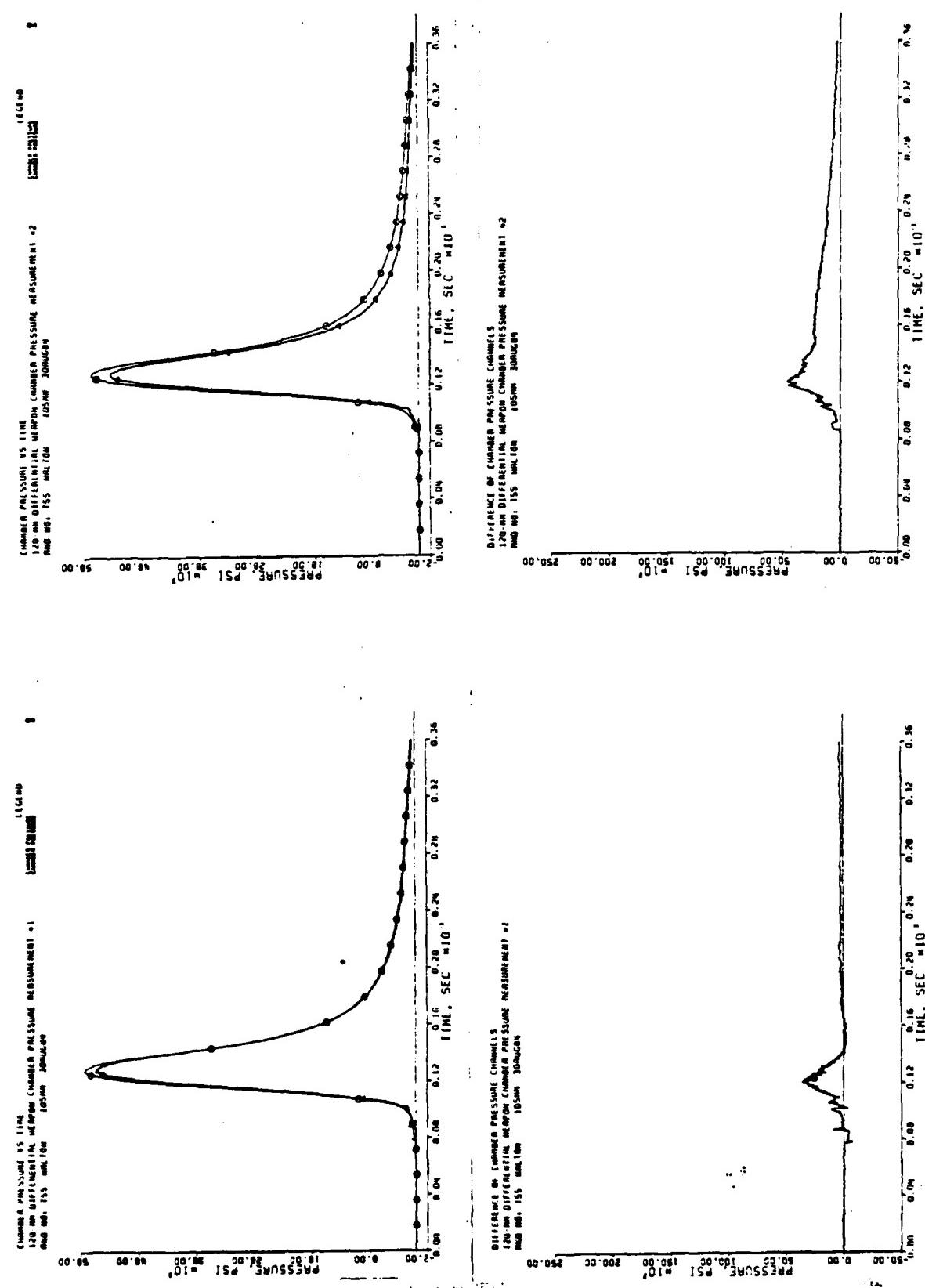


Figure 2.6-8a. Round No. T55.

2.6 (Cont'd)

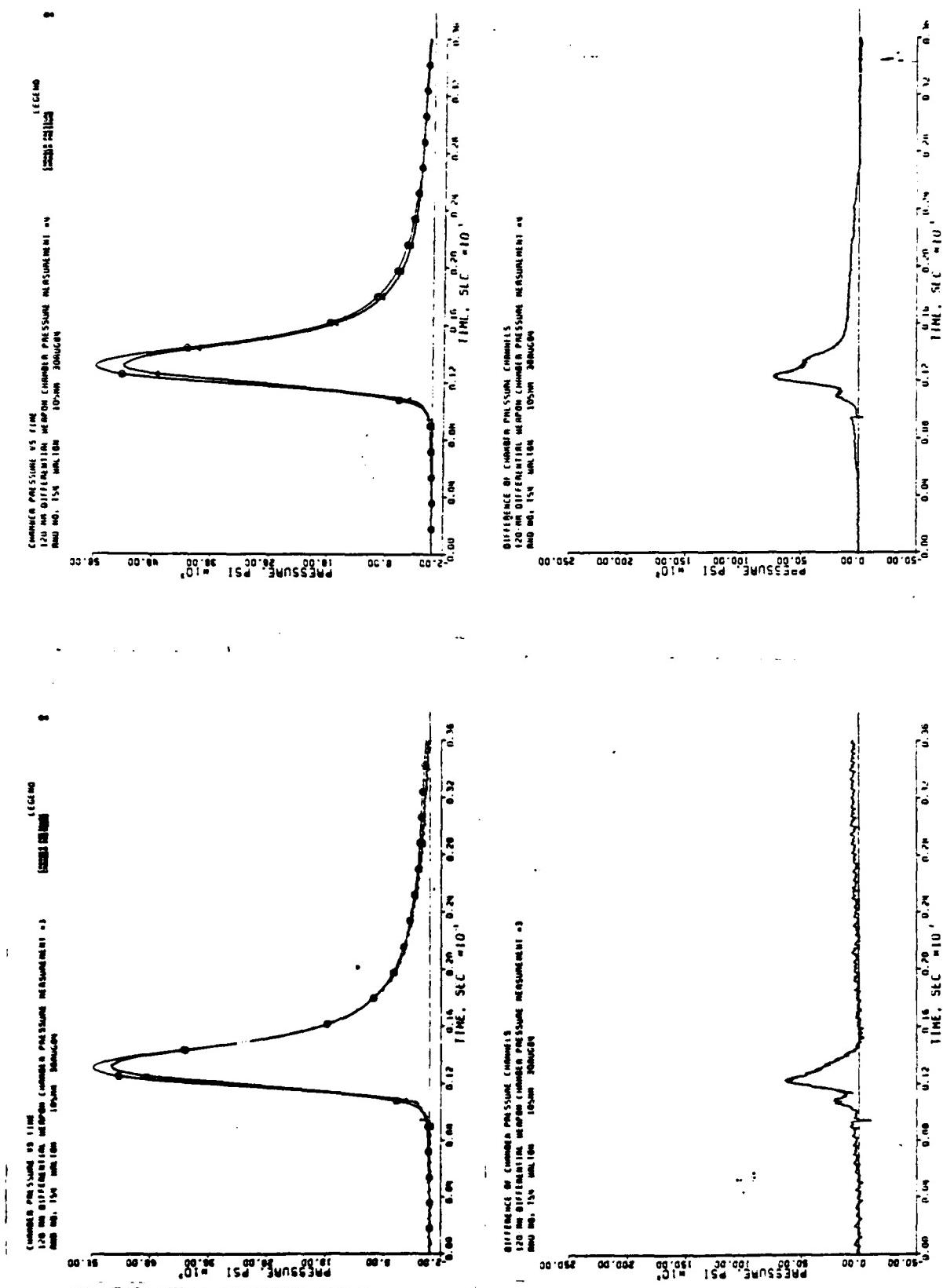


Figure 2.6-7b. — Round No. T54.

## 2.6 (Cont'd)

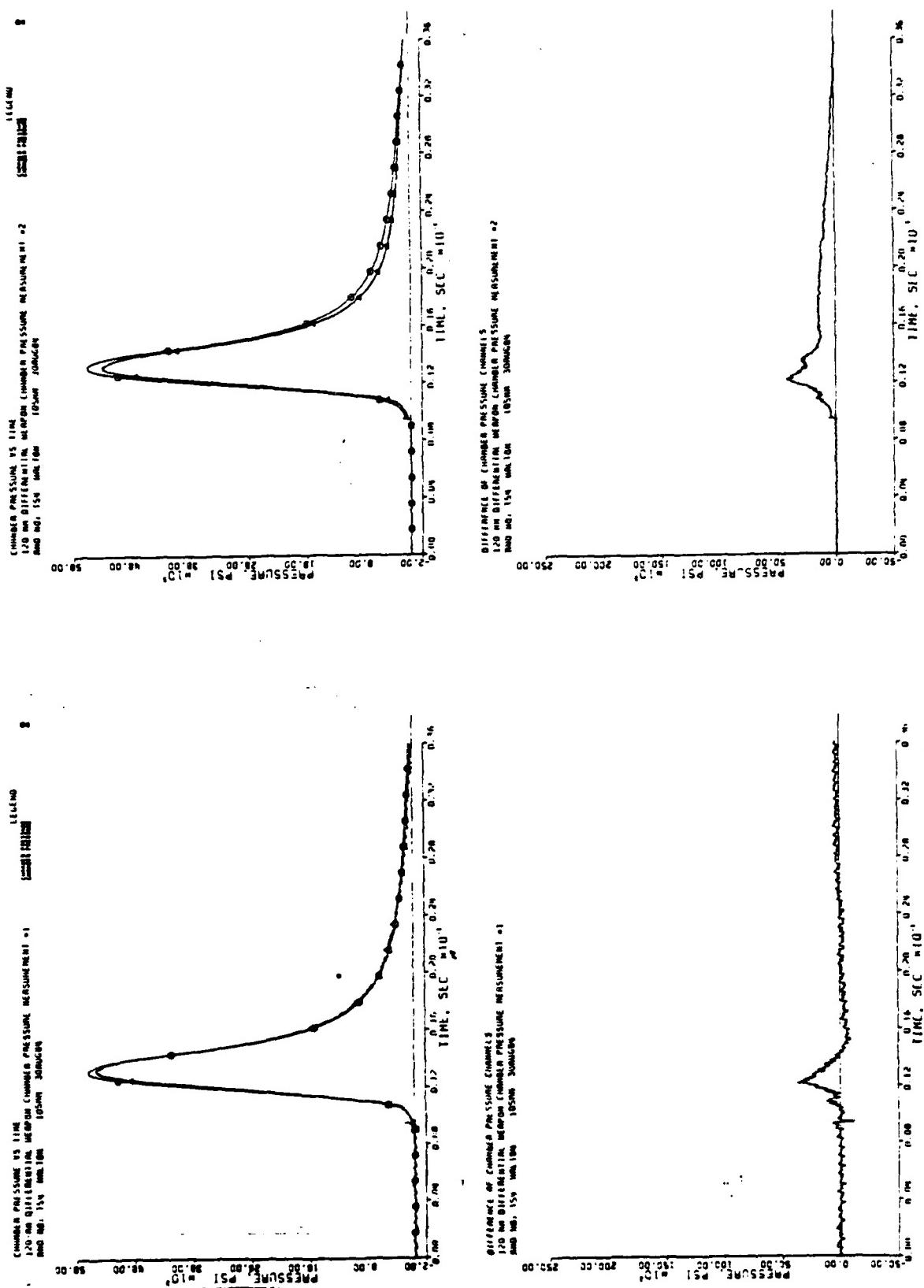


Figure 2.6-7a. - Round No. T54.

## 2.6 (Cont'd)

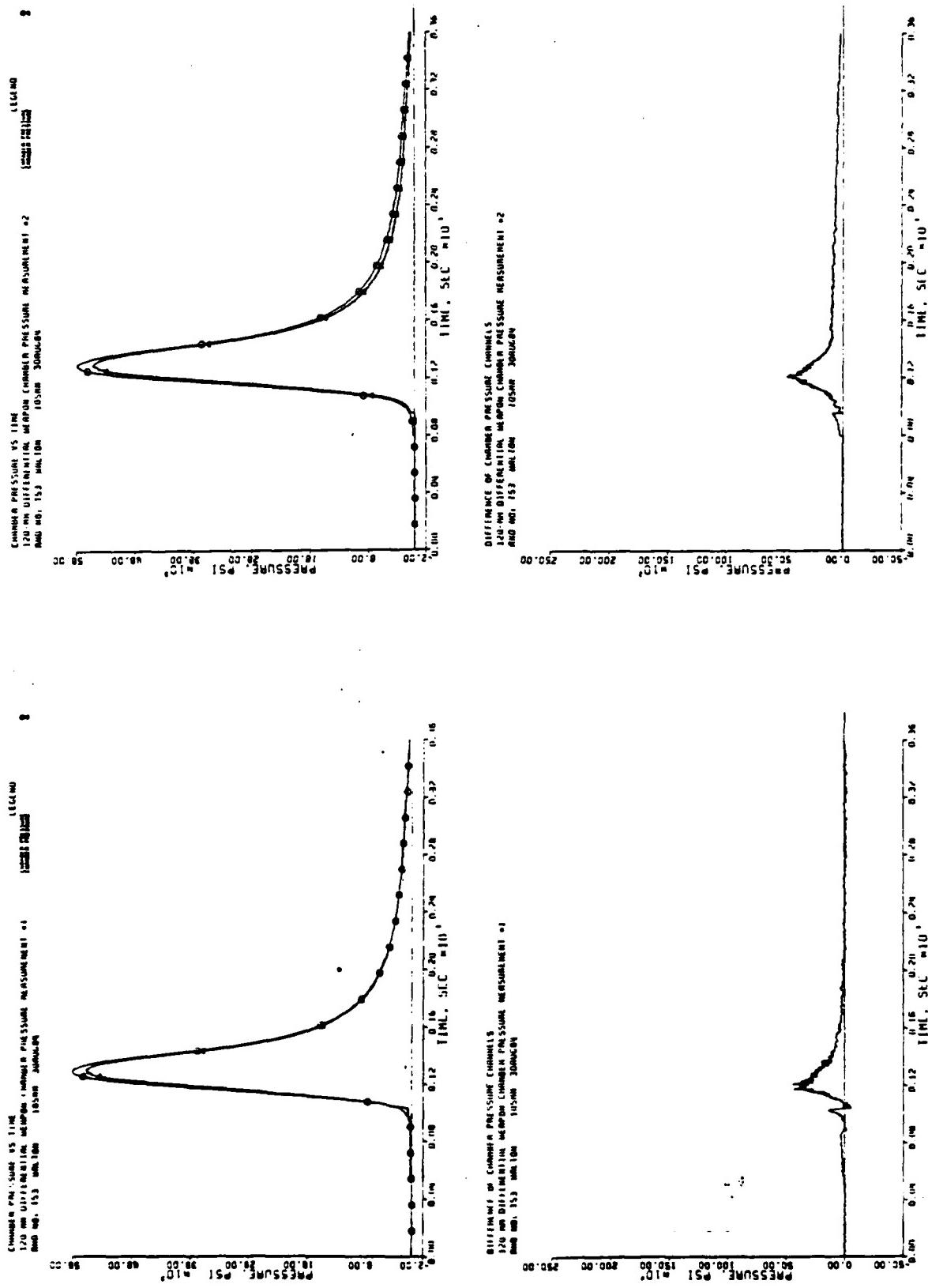


Figure 2.6-6. Round No. T53.

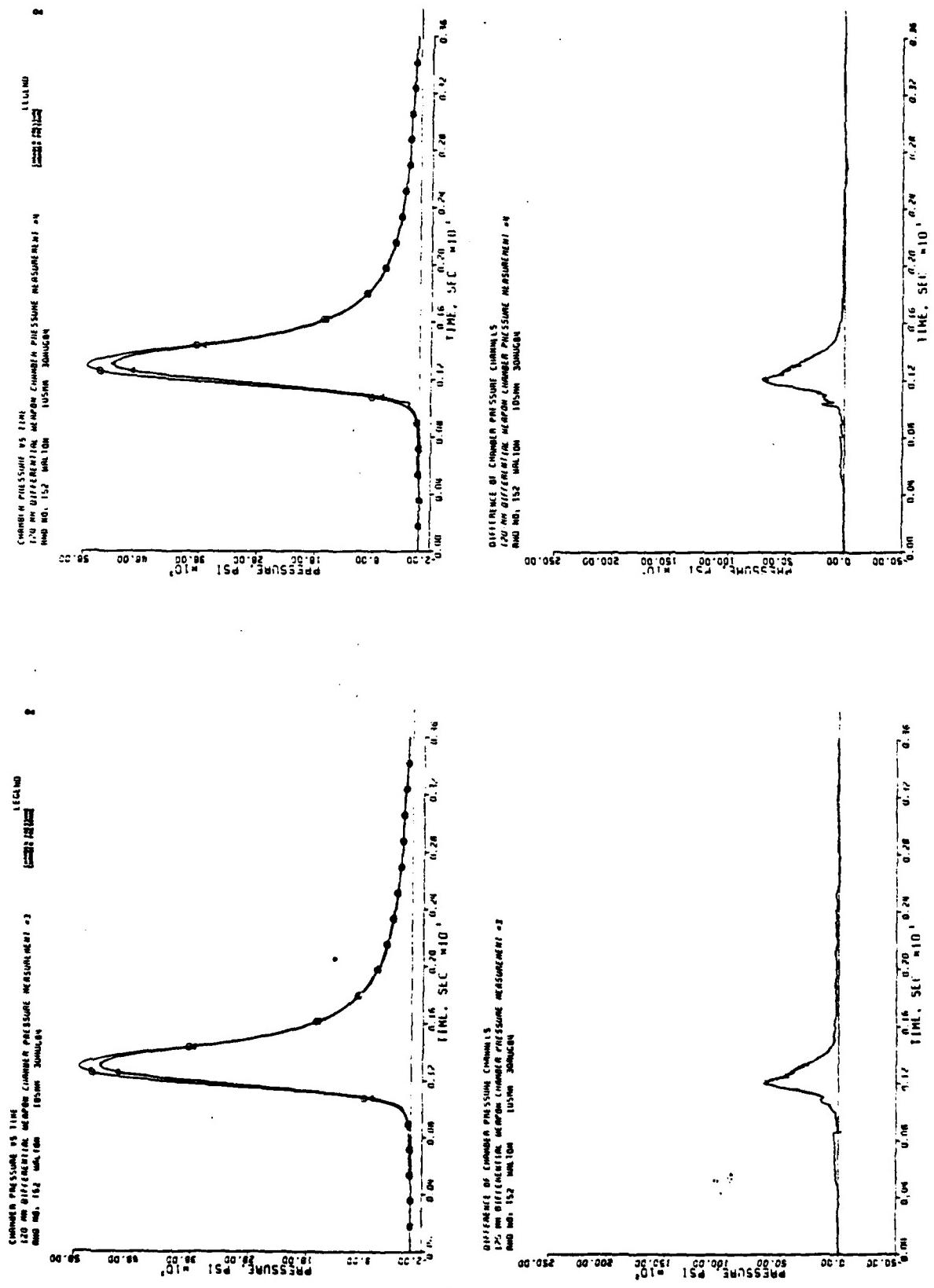


Figure 2.6-5b. Round No. T52.

2.6 (Cont'd)

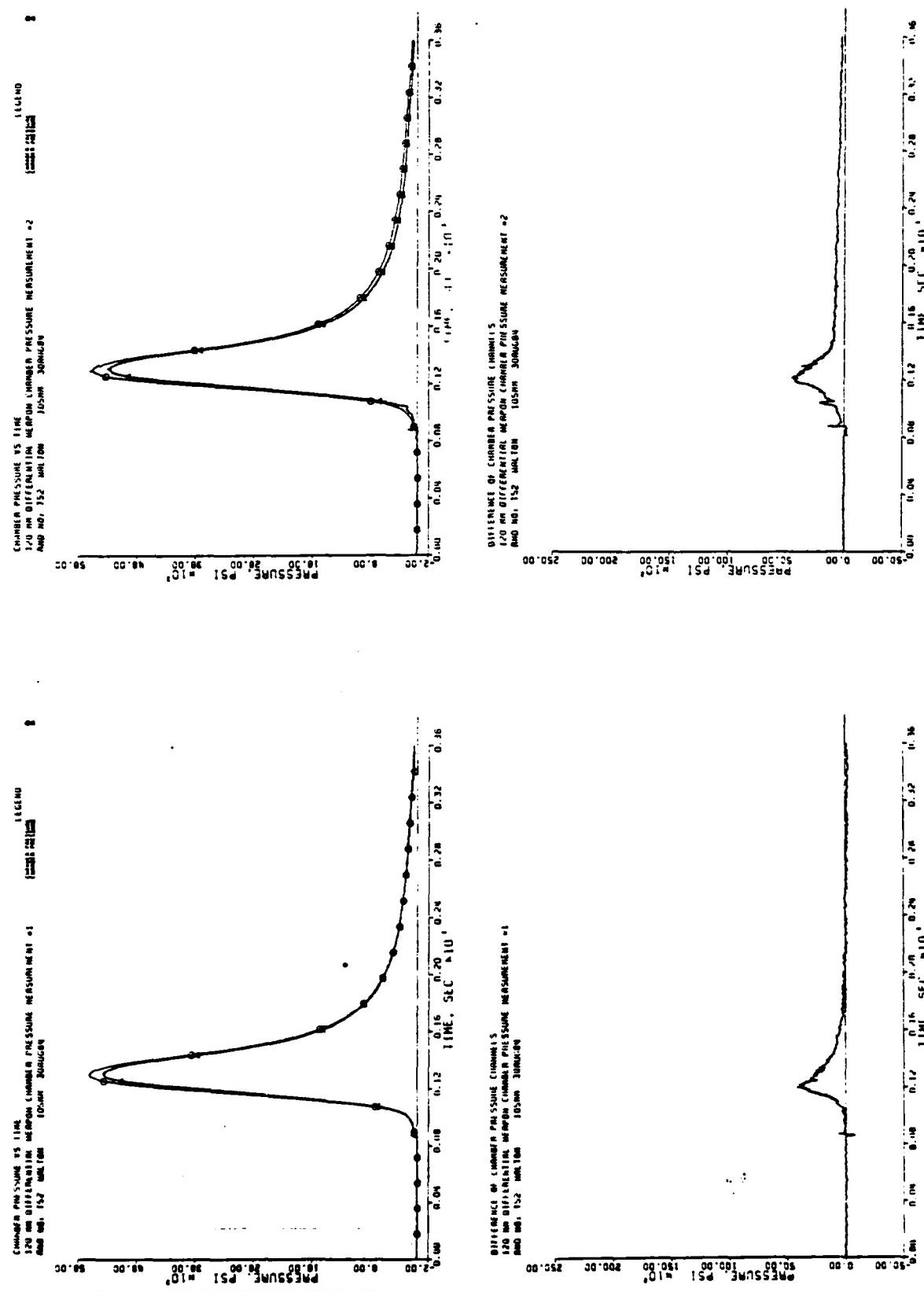


Figure 2.6-5a. Round No. T52.

2.6 (Cont'd)

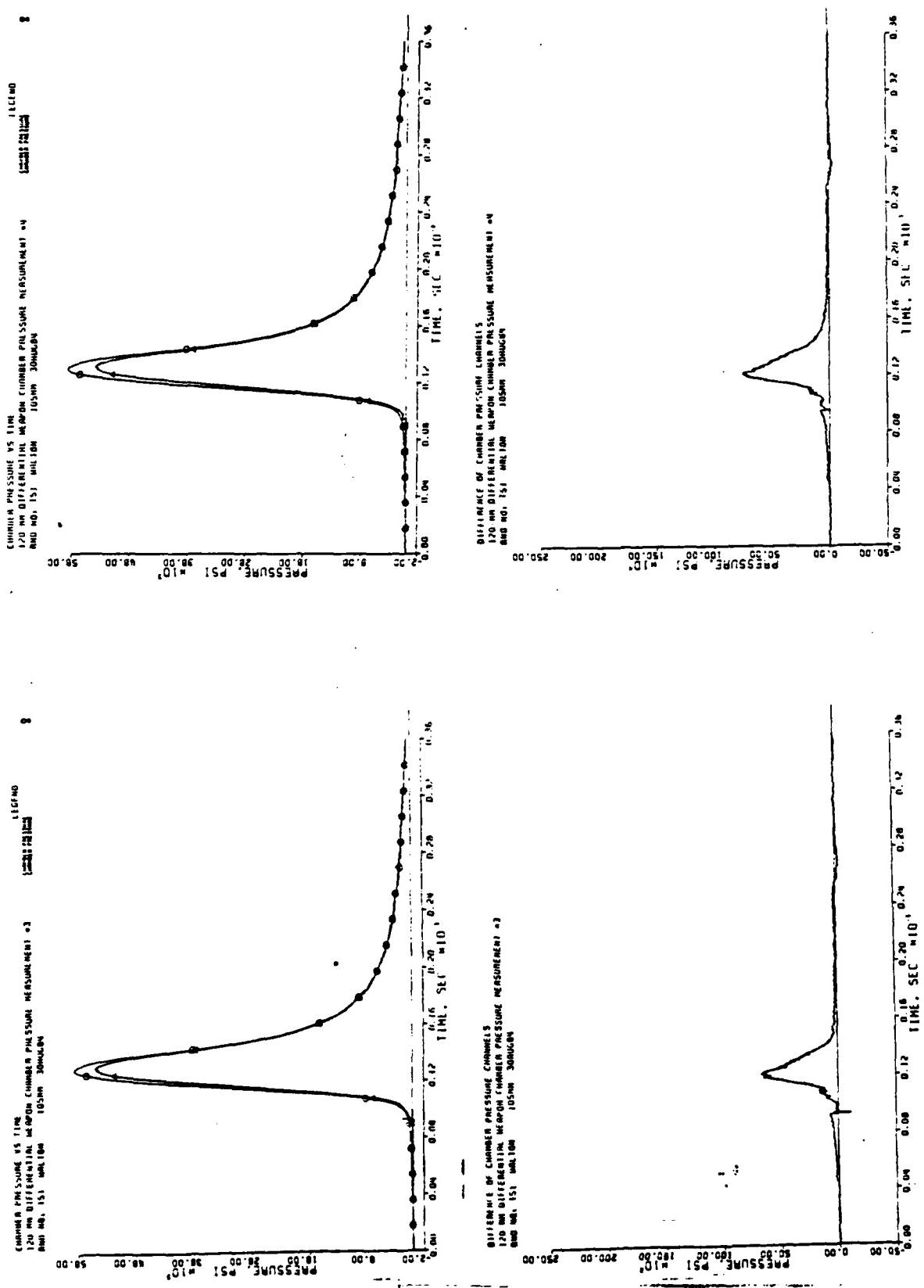


Figure 2.6-4b. Round No. T51.

2.6 (Cont'd)

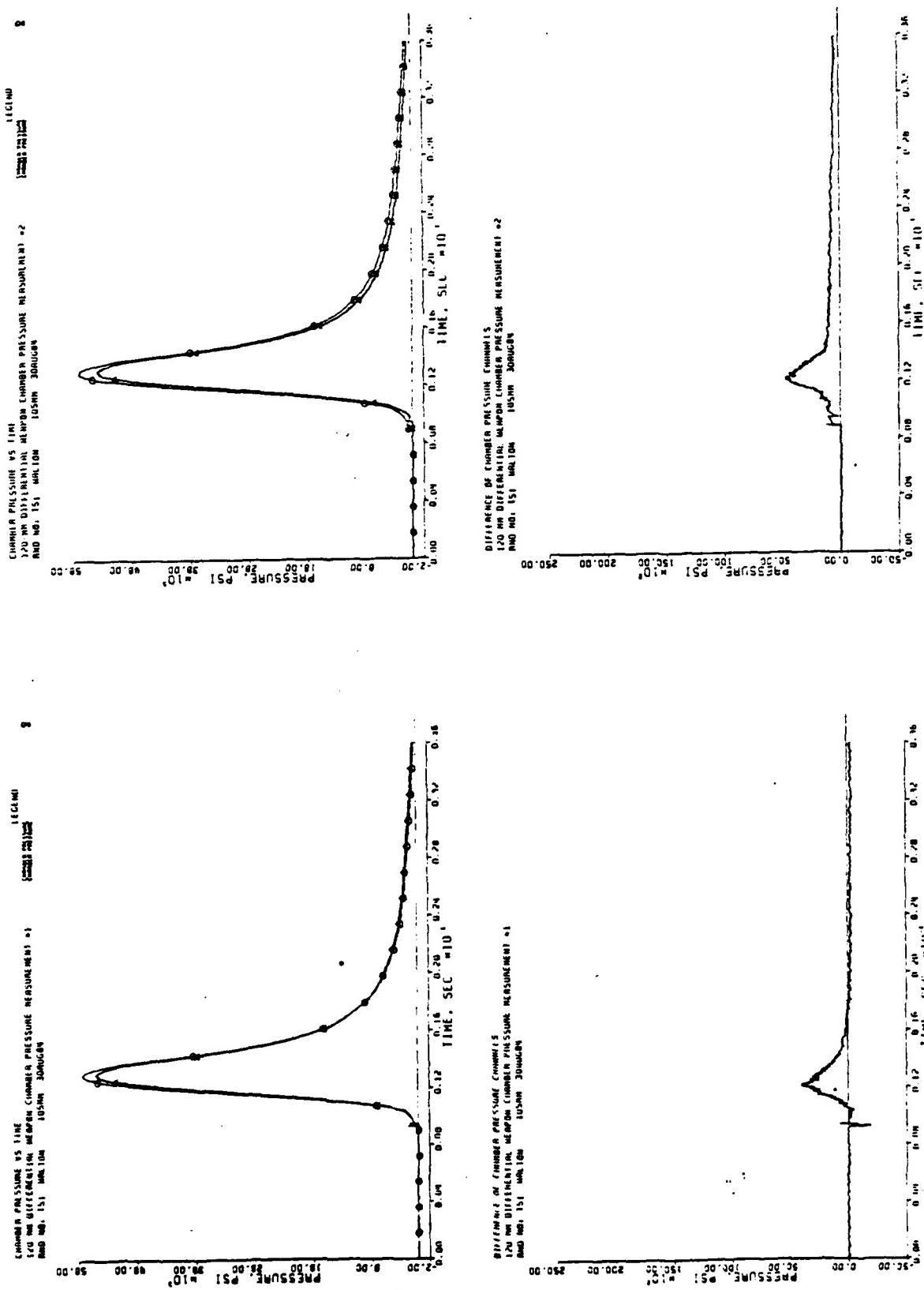


Figure 2.6-4-a. Round No. T51.

2.6 (Cont'd)

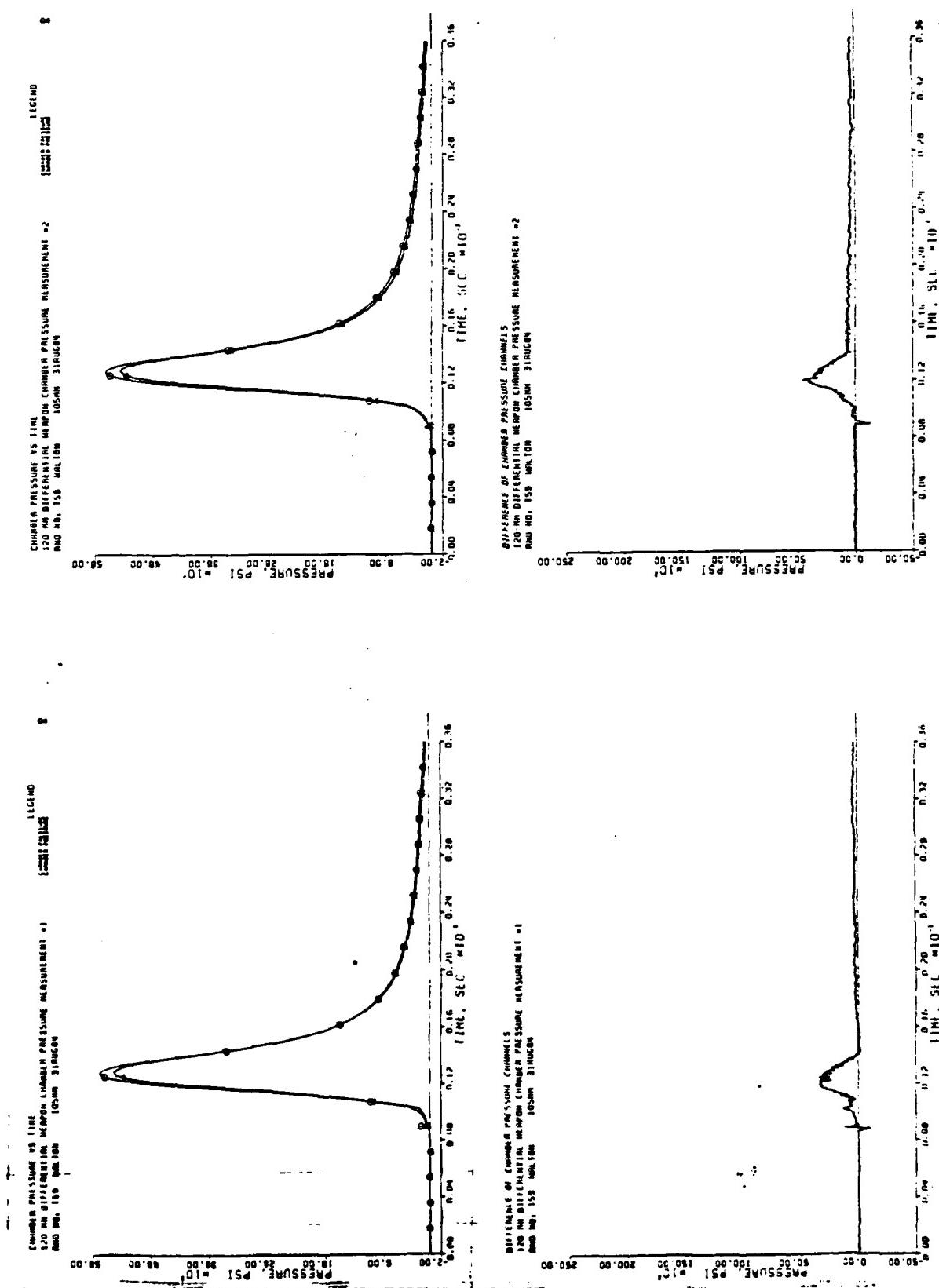


Figure 2.6-12a. Round No. T59.

2.6 (Cont'd)

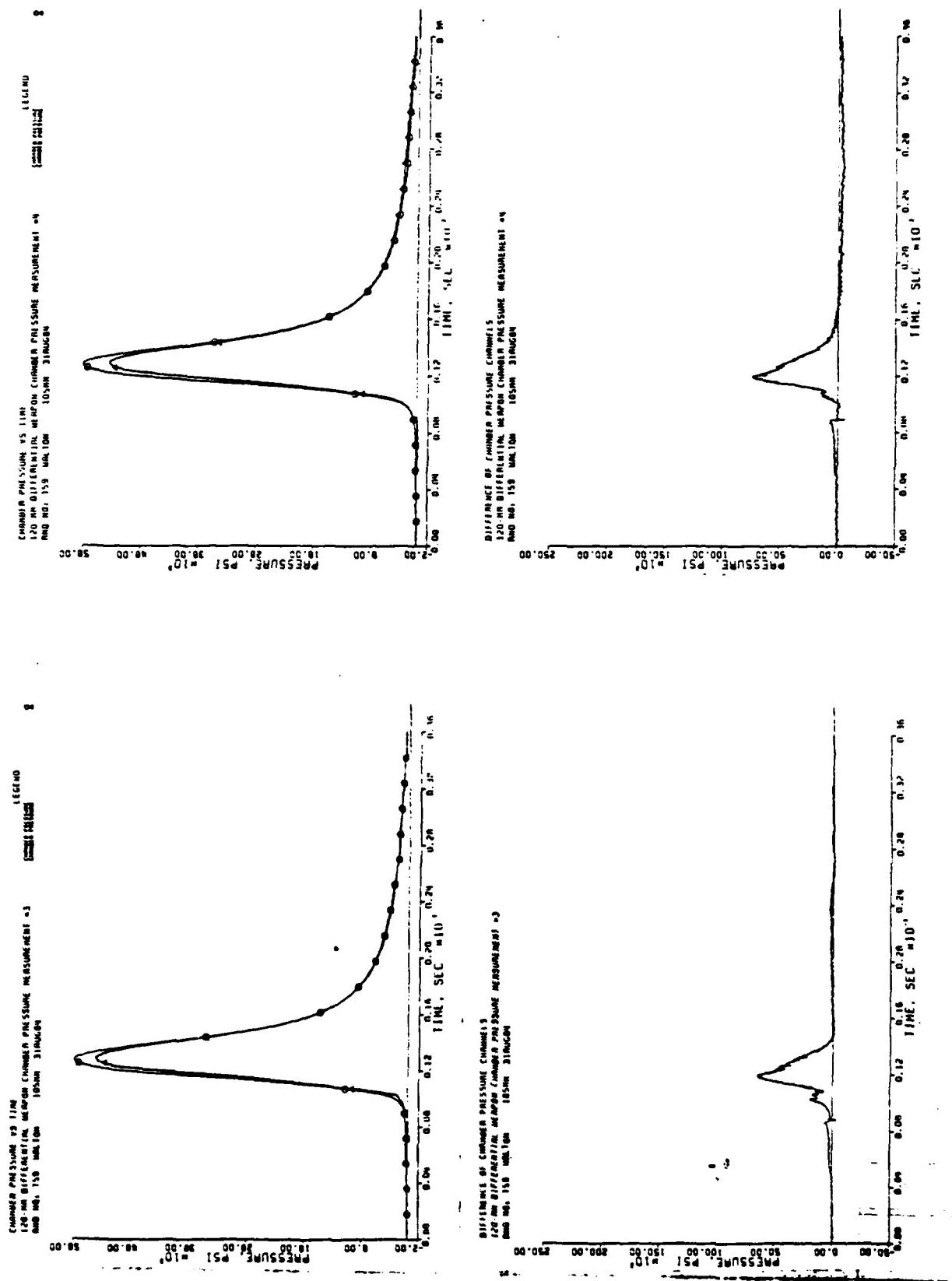


Figure 2.6-12b. Round No. T59.

2.6 (Cont'd)

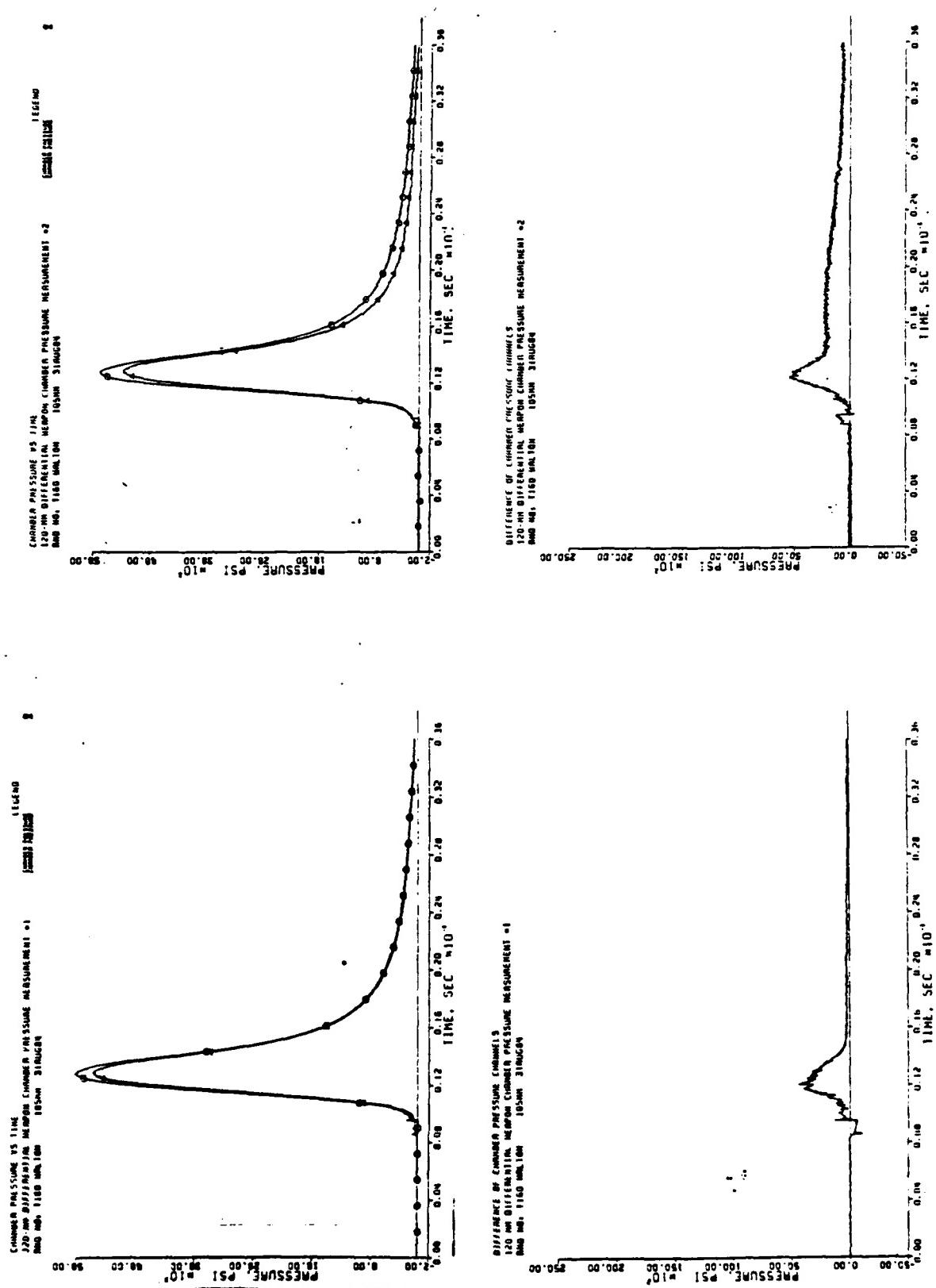


Figure 2.6-13a. Round No. T160.

2.6 (Cont'd)

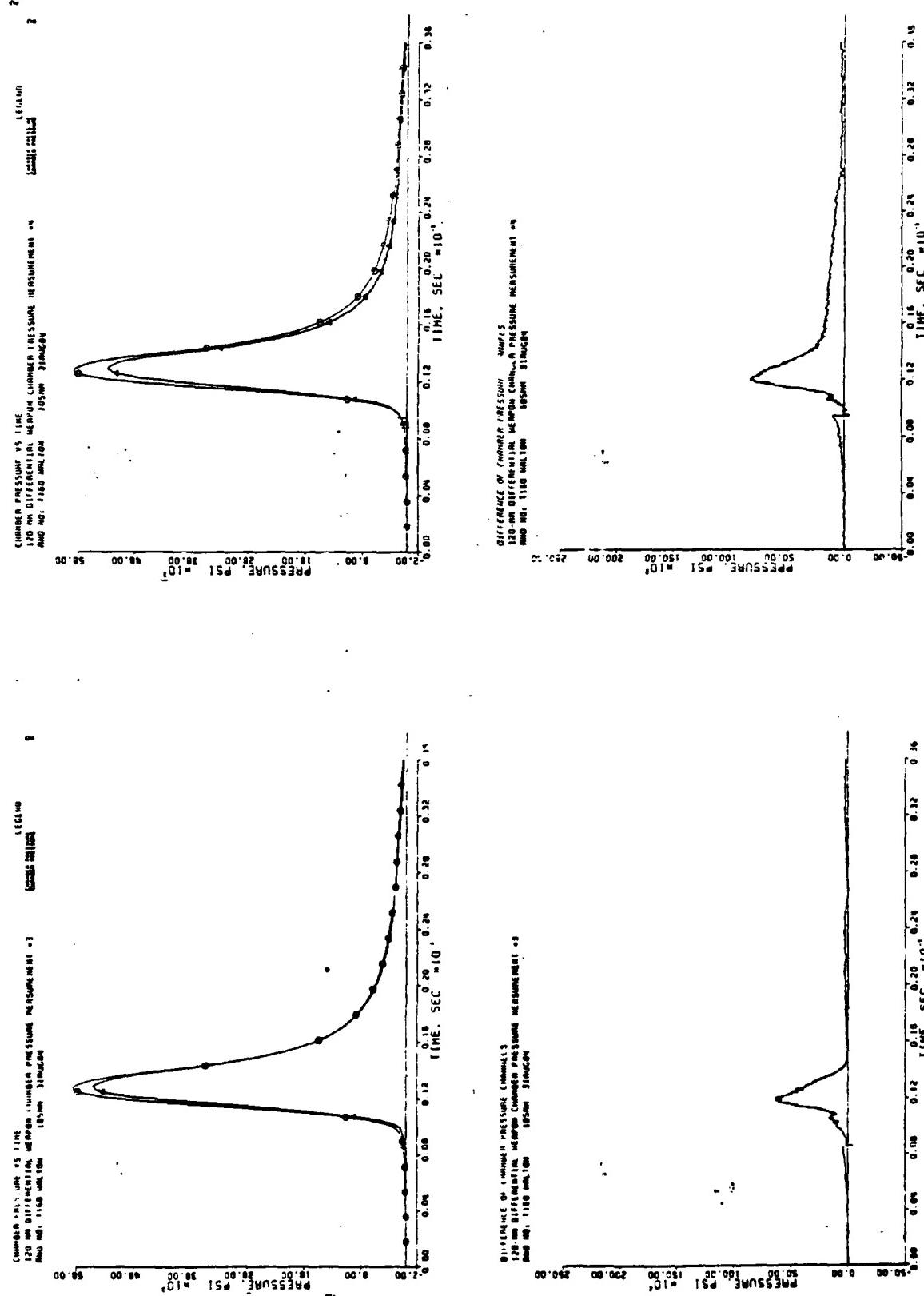


Figure 2.6-13b. Round No. T160.

## 2.7 PHASE IIa. ROUNDS 61 THROUGH 66, TUBE 25151

Yuma E15MA gages No. 7 and 8 were mounted in the right side of the tube, and gage positions were interchanged after three rounds. The test phase was conducted with the 316 charge amplifiers for both right and left pair of gages. No adapters were used during this phase for either pair of gages. Kistler gages 168650 and 168659 were used in the left side of the tube. To this point in the test, these gages have given good data, but in a different tube.

The E15MA pair of gages exhibit several cable separation problems and an inconsistent return to zero on the differential plots. Negative offset of the differential record, slowly returning to zero and passing through zero are all prevalent effects in the differential plots. Although the differential peak pressures are not unusually bad, the peak pressures indicate problems with gage E15MA No. 7.

The performance of this pair of Kistler gages is good, as in previous firings. Differential pressure plots are slightly noisy but well shaped with good returns to zero. Both peak pressures and differential peak pressures are in agreement with expected results.

105-mm Tank Gun  
Tube SN 25151  
Cartridge: M392A2  
Temperature: +70° F  
Date Fired: 4 September

TABLE 2.7-1. CHAMBER PRESSURE DATA - PHASE II<sup>a</sup>

## 2.7 (Cont'd)

Expt No.	HISMA No. 7		HISMA No. 8		Kistler No. 168650		Kistler No. 168659		Kistler No. 168659		Maxium Chamber Pressure, Kpsi		Base - Forward		Base - Forward			
	Ch. 1	AMP Position	Ch. 2	AMP Position	Ch. 3	AMP Position	Ch. 4	AMP Position	Ch. 5	AMP Position	Gage	Gage	Ch. 1 or 2	Channels 3 or 4	Ch. 1 or 2	Channels 3 or 4		
T61	452.6	316	Rear	54.5	316	Forward	57.2	316	Rear	54.8	316	Forward	58.3	316	Base	690	4660	6500
T62	56.0	316	Rear	54.7	316	Forward	58.2	316	Rear	55.0	316	Forward	58.8	316	Base	3030	3940	6300
T63	57.9	316	Rear	54.8	316	Forward	58.7	316	Rear	55.6	316	Forward	59.4	316	NR	4090	4270	NA
T64	52.3	316	Forward	56.9	316	Rear	57.2	316	Rear	54.8	316	Forward	58.6	316	Base	4850	4040	7600
T65	52.3	316	Forward	56.6	316	Rear	56.8	316	Rear	54.6	316	Forward	58.4	316	Base	4840	4810	6900
T66	54.6	316	Forward	57.6	316	Rear	58.4	316	Rear	55.6	316	Forward	59.5	316	Base	4310	4380	7100

age blockage; misalignment of rear gage.

C4 - Channel.

2.7 (Cont'd)

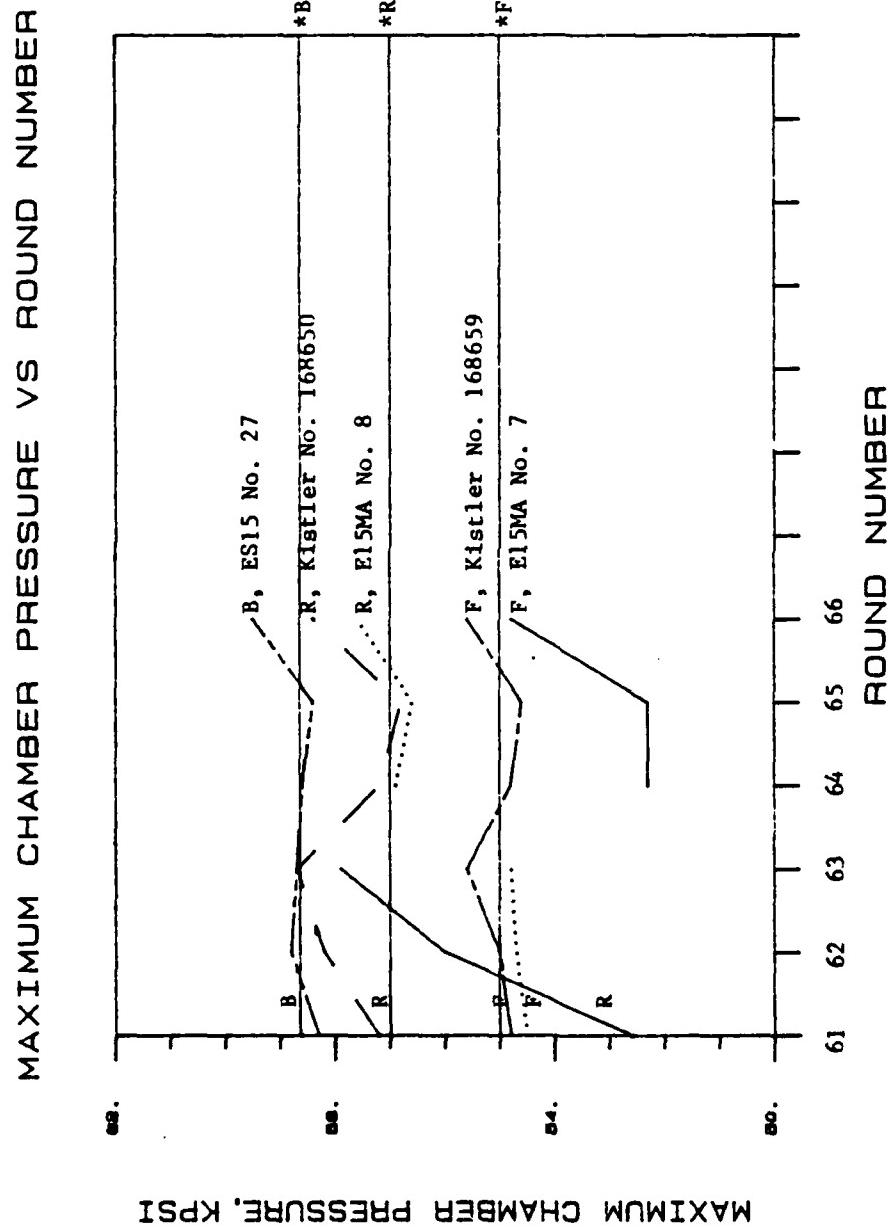
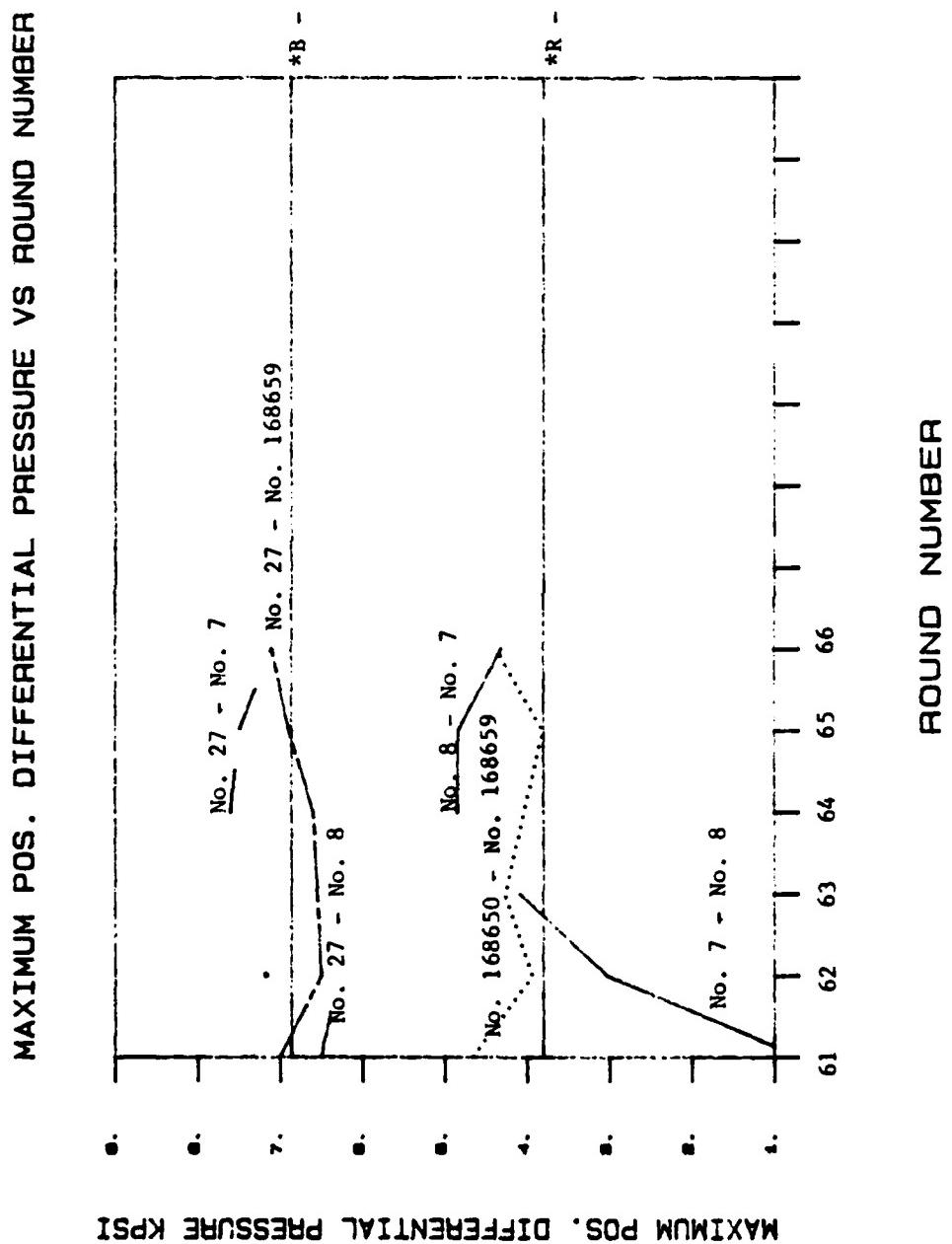


Figure 2.7-1(1). Maximum chamber pressure.

2.7 (Cont'd)



R - F = Rear minus forward gage.  
 B - F = Base minus forward gage.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.7-1(2). Maximum positive differential pressure.

2.7 (Cont'd)

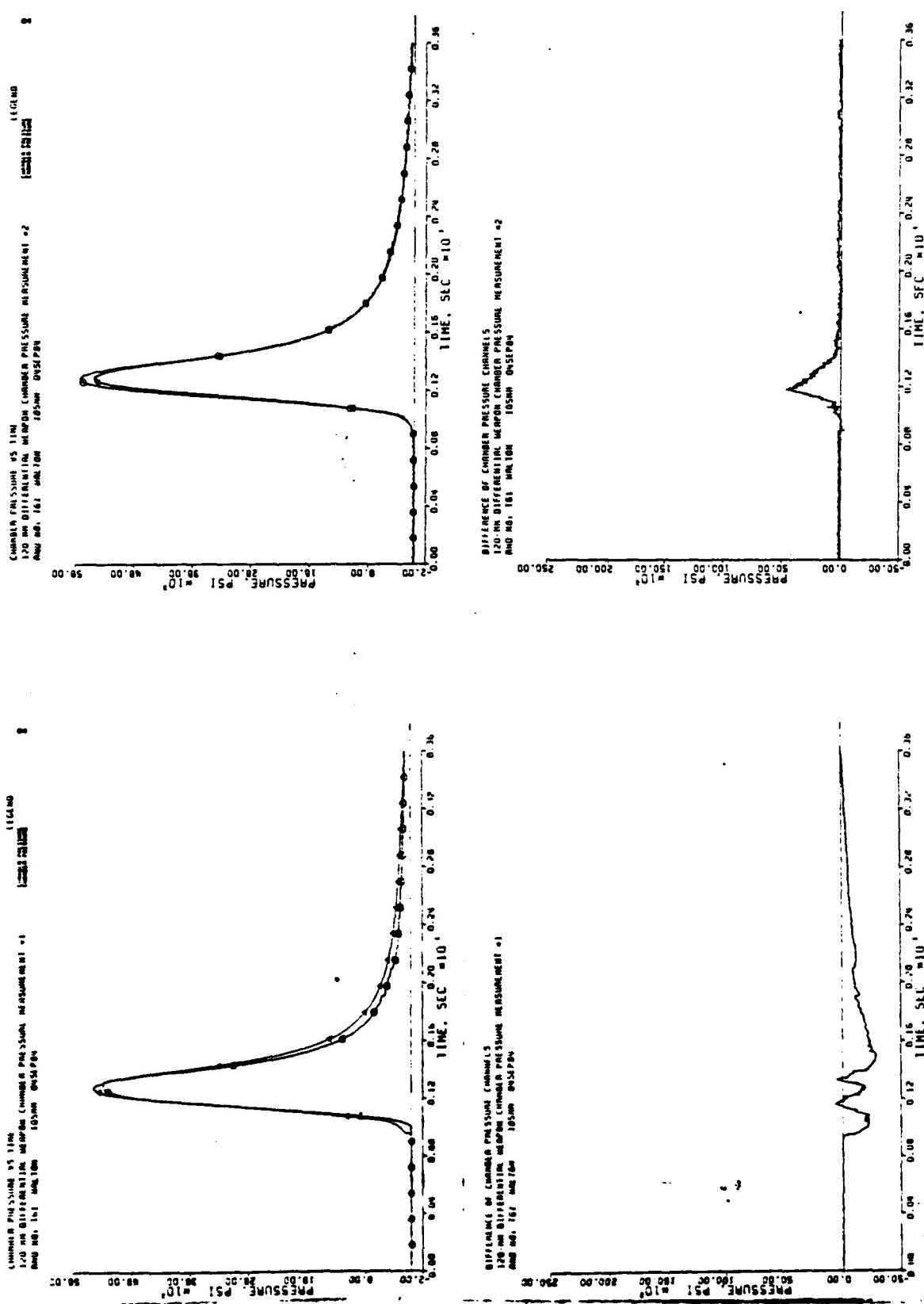


Figure 2.7-1a. Round No. T61.

2.7 (Cont'd)

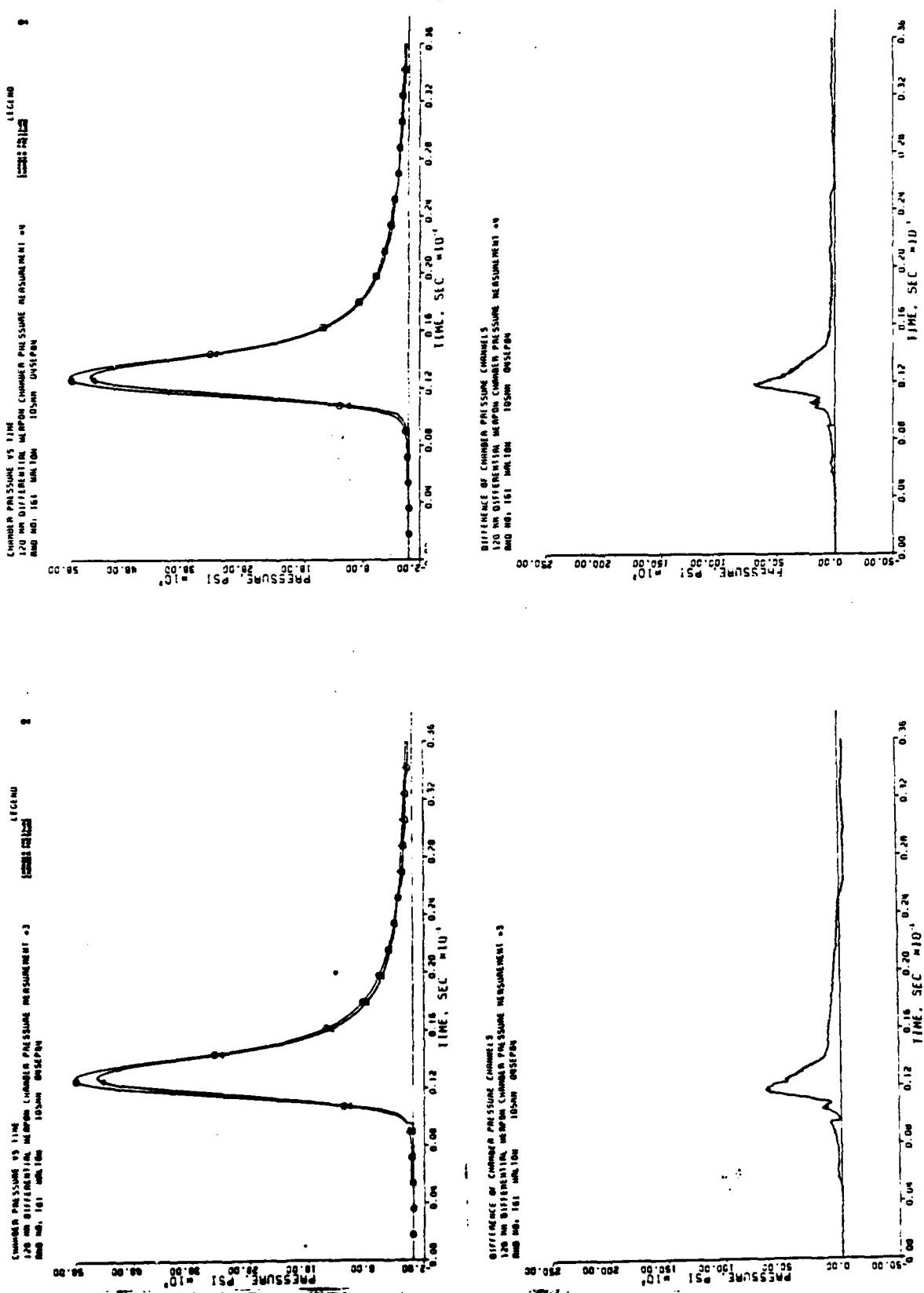


Figure 2.7-1b. Round No. T61.

2.7 (Cont'd)

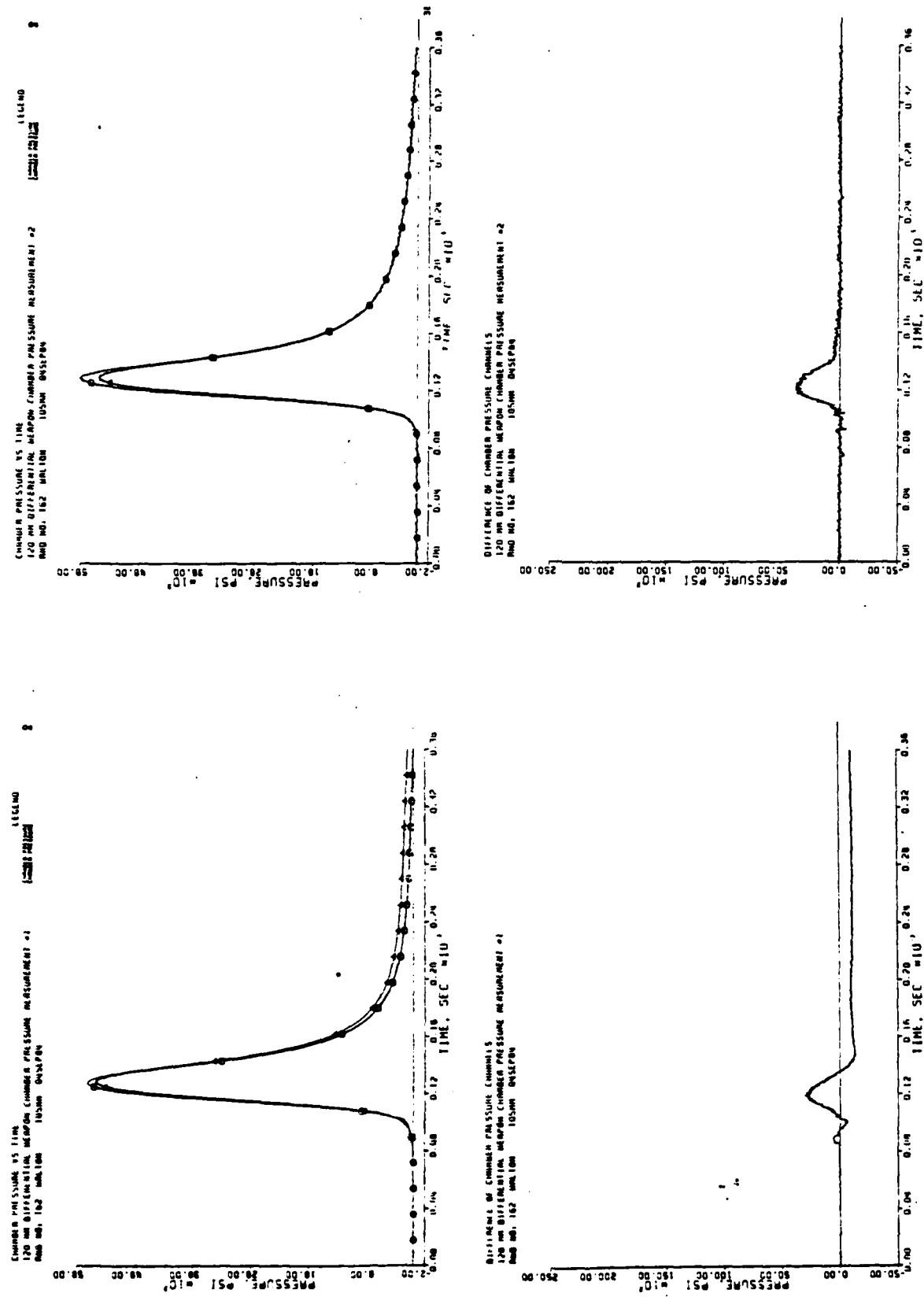


Figure 2.7-2a. Round No. T62.

2.7 (Cont'd)

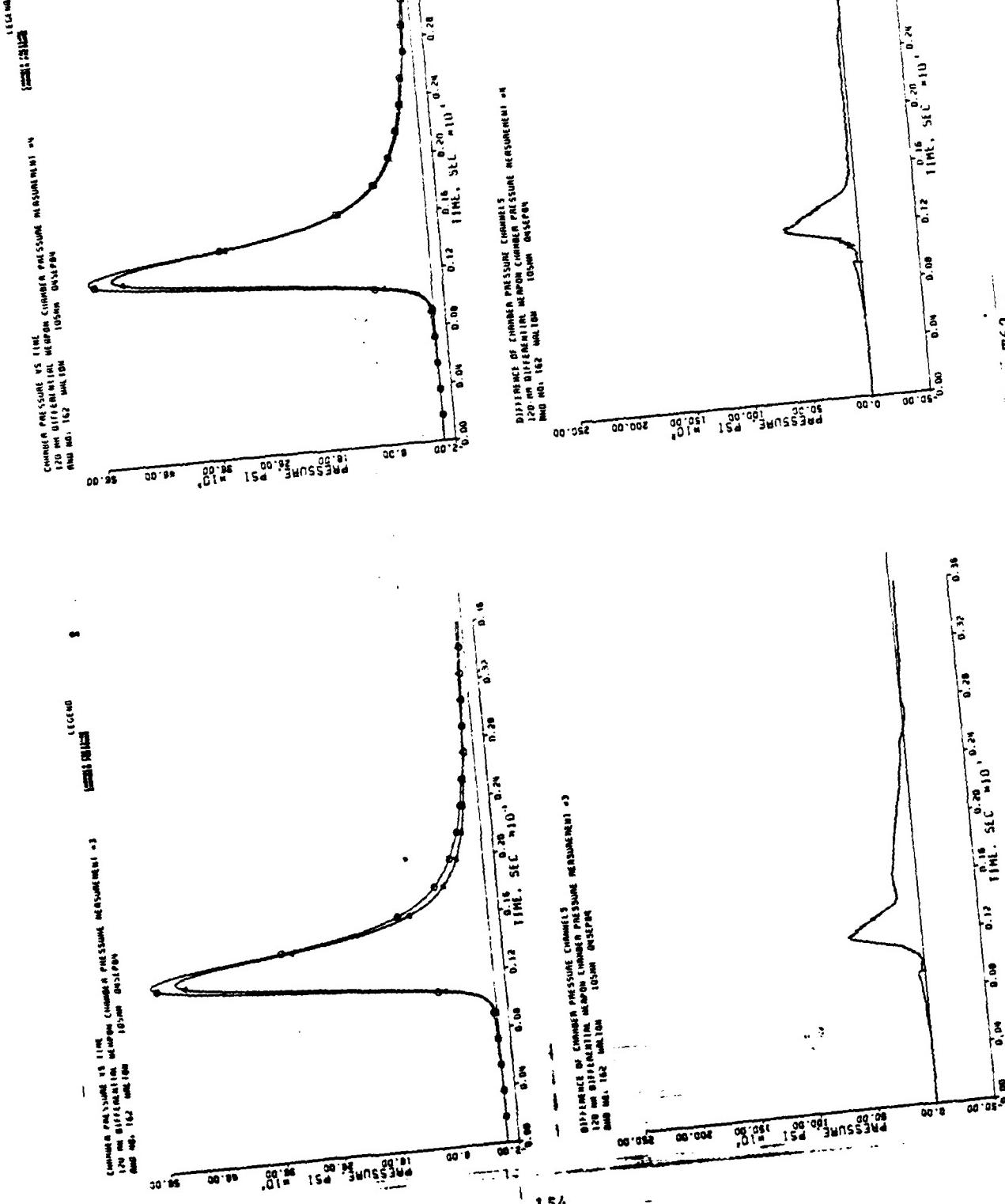


Figure 2.7-2b. Round No. T62.

2.7 (Cont'd)

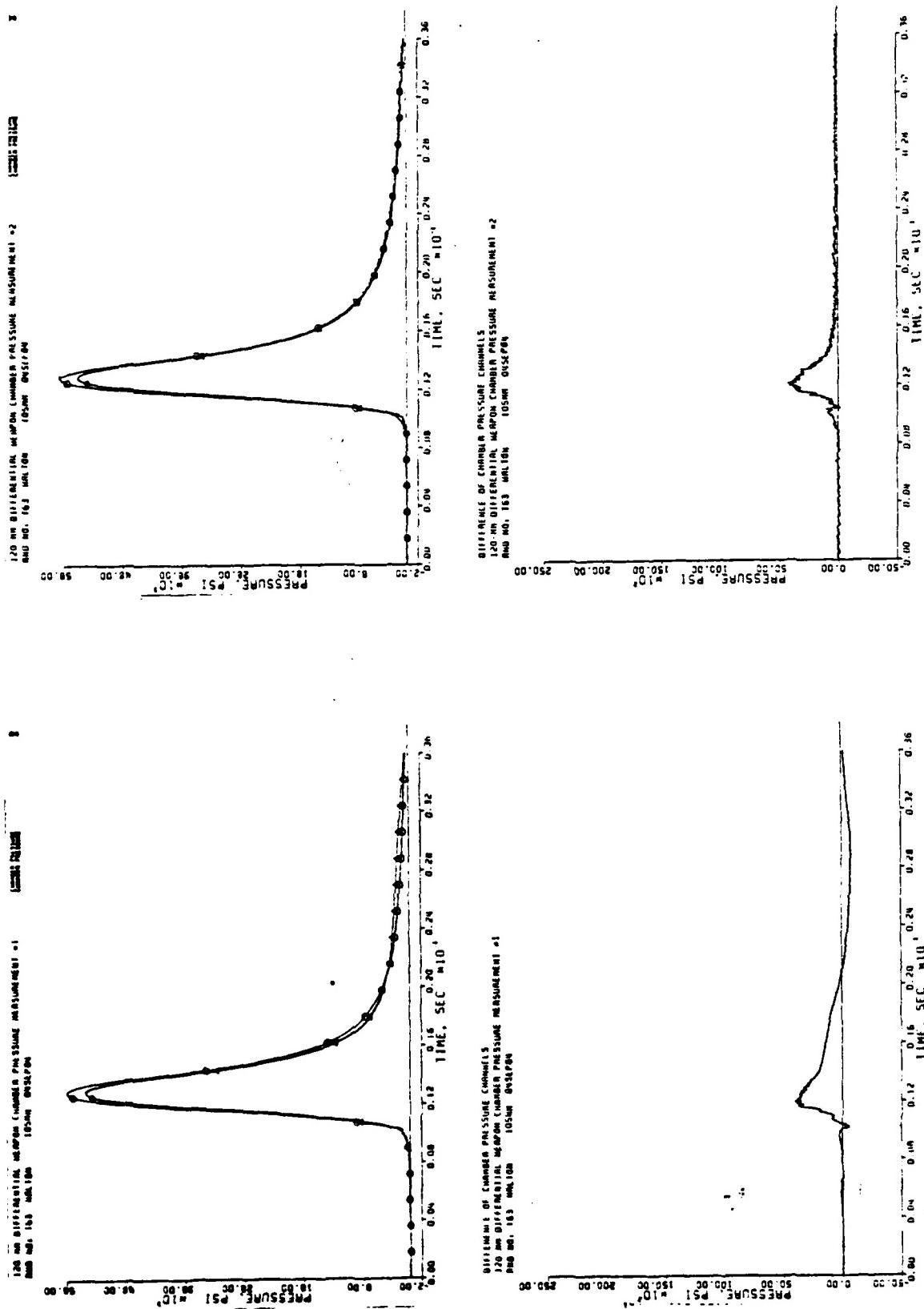


Figure 2.7-3. Round No. T63.

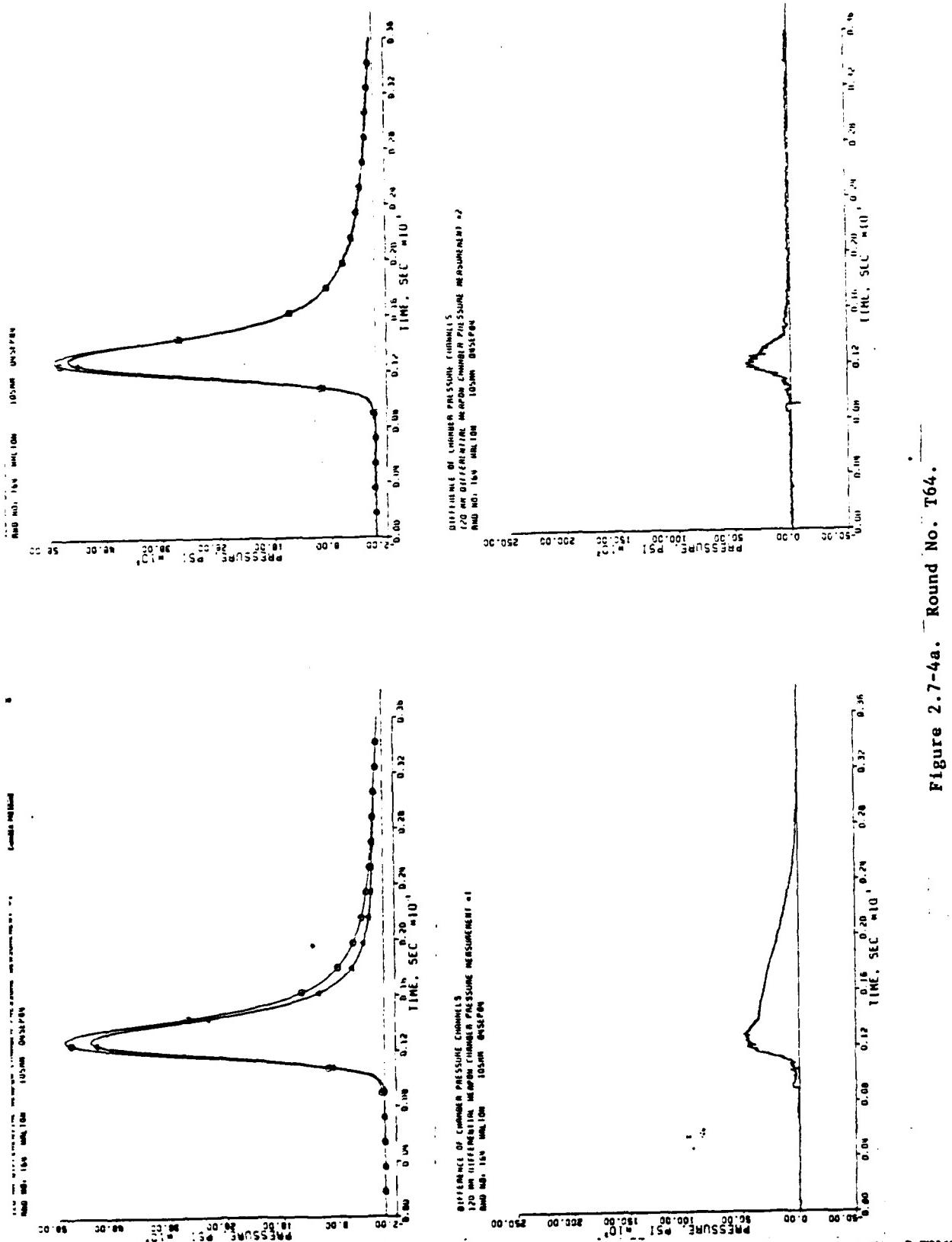


Figure 2.7-4a. — Round No. T64.

.8 (Cont'd)

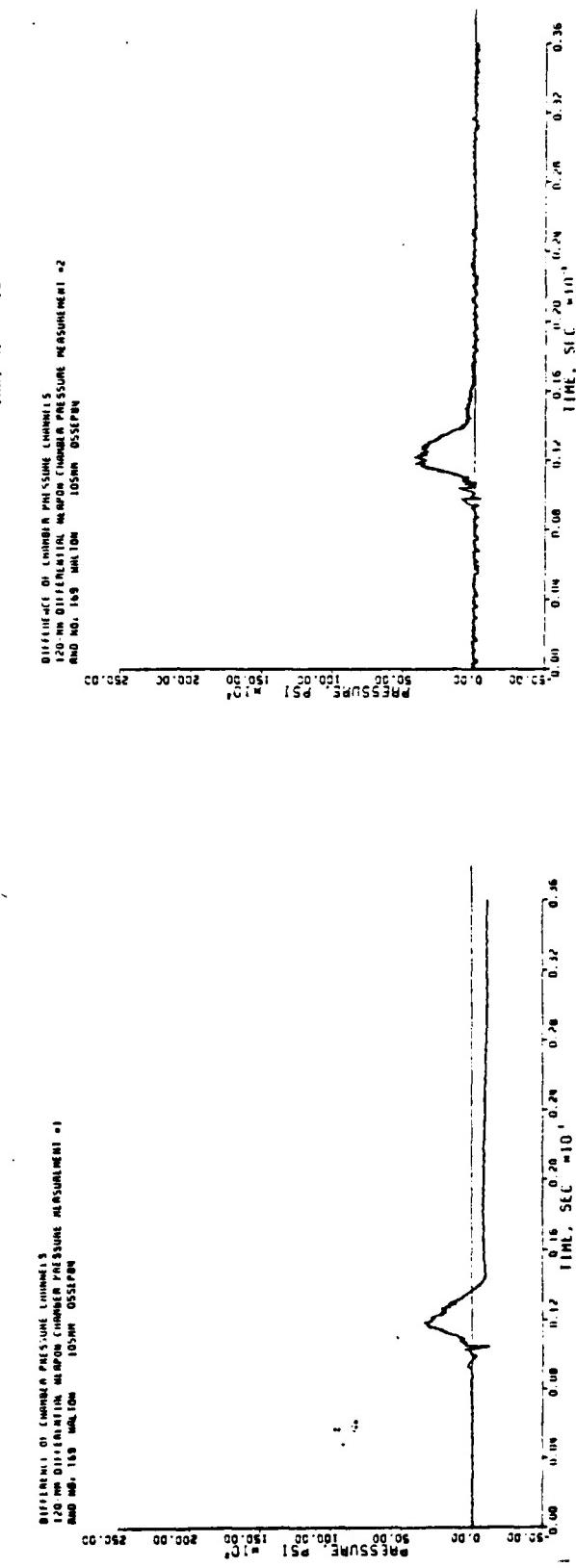
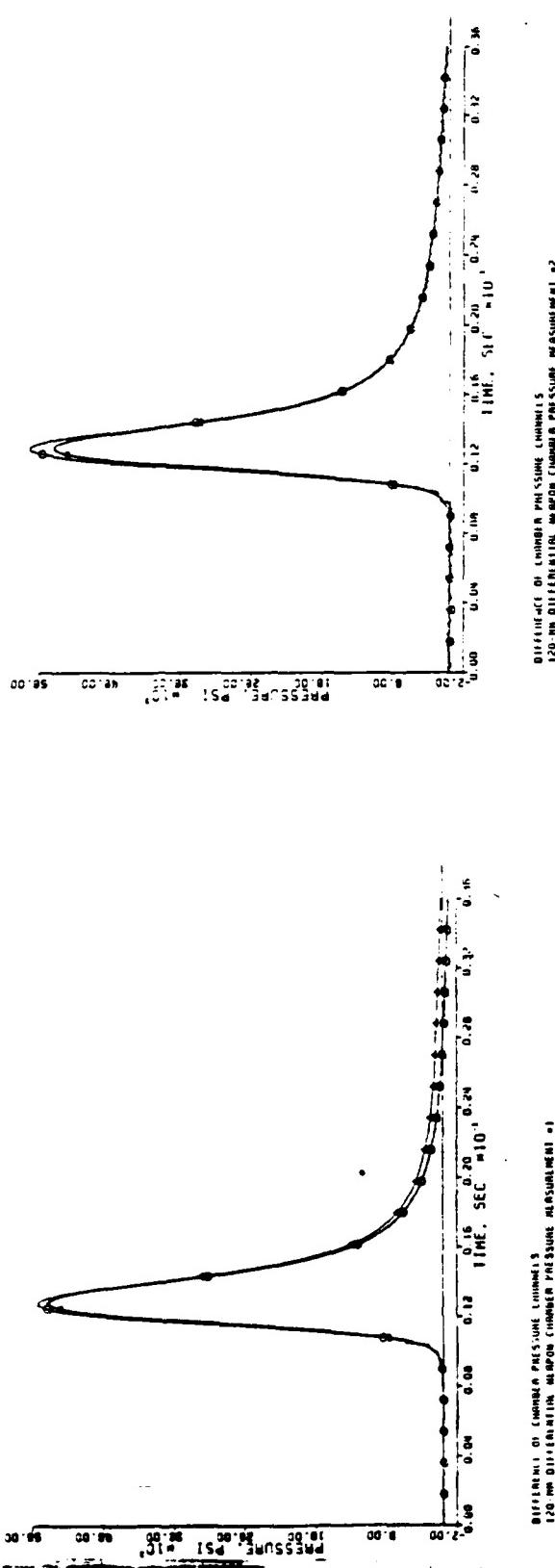


Figure 2.8-3a. Round No. T69.

2.8 (Cont'd)

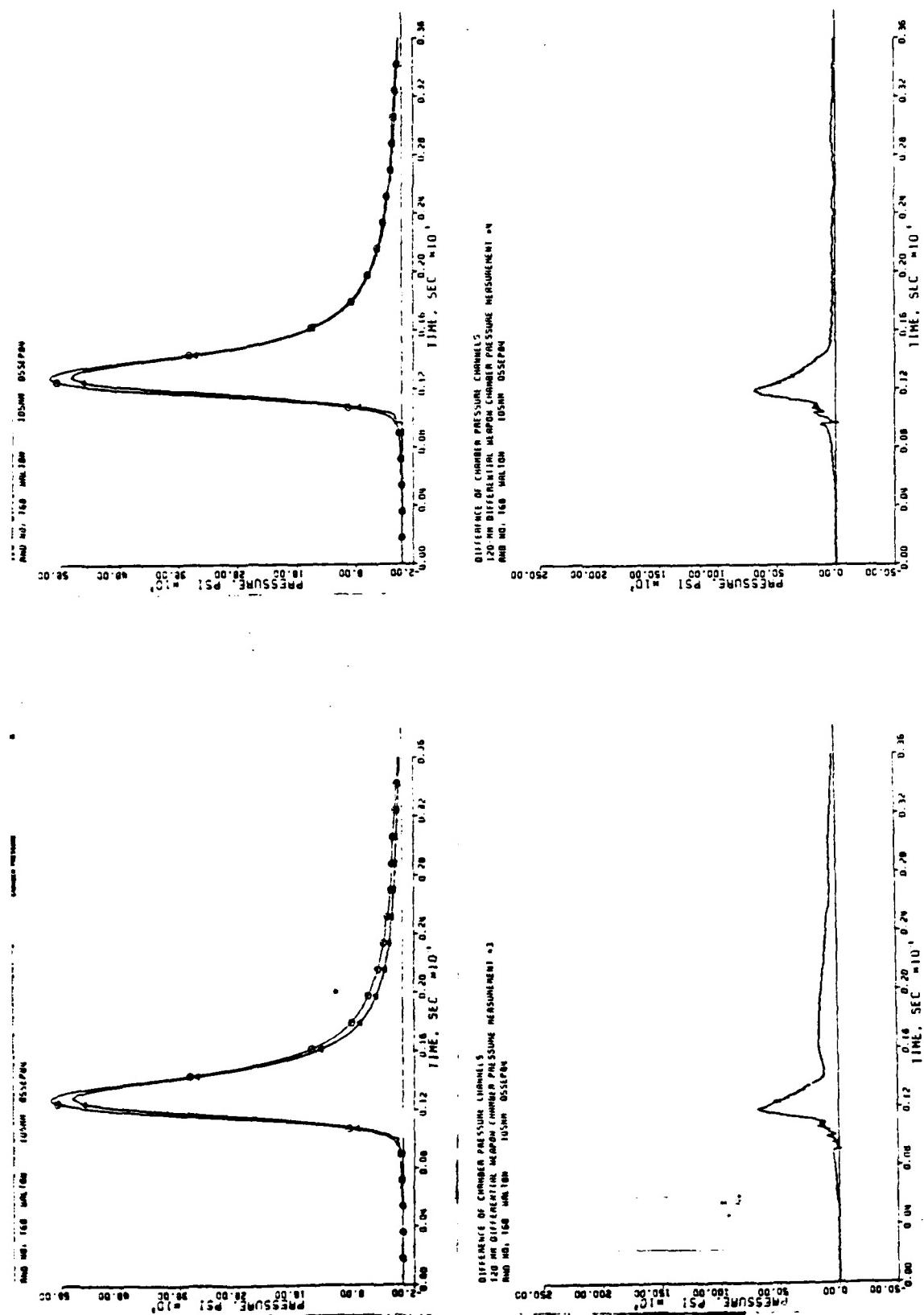


Figure 2.8-2b. Round No. 168.

2.8 (Cont'd)

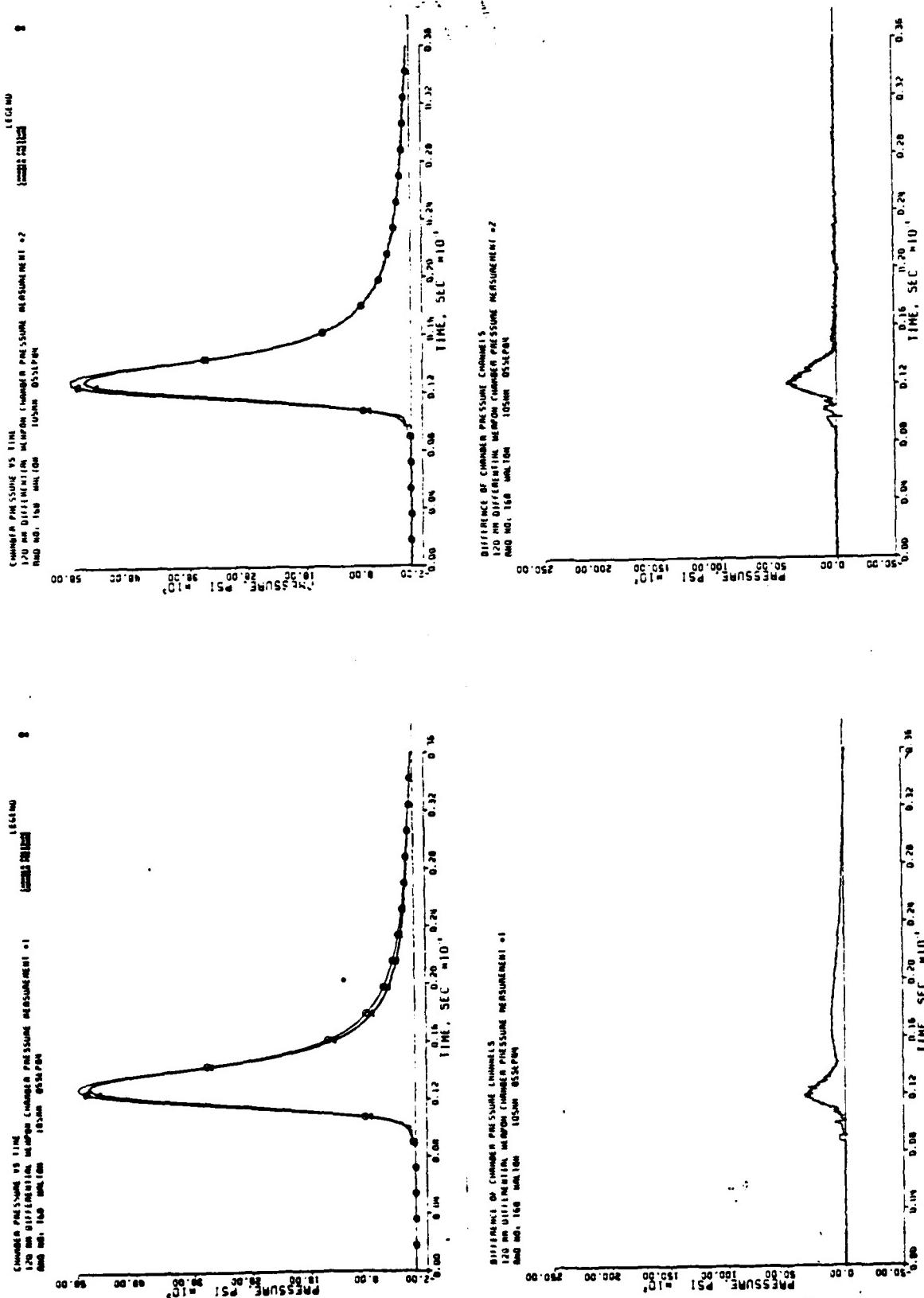


Figure 2.8-2a. Round No. T68.

2.8 (Cont'd)

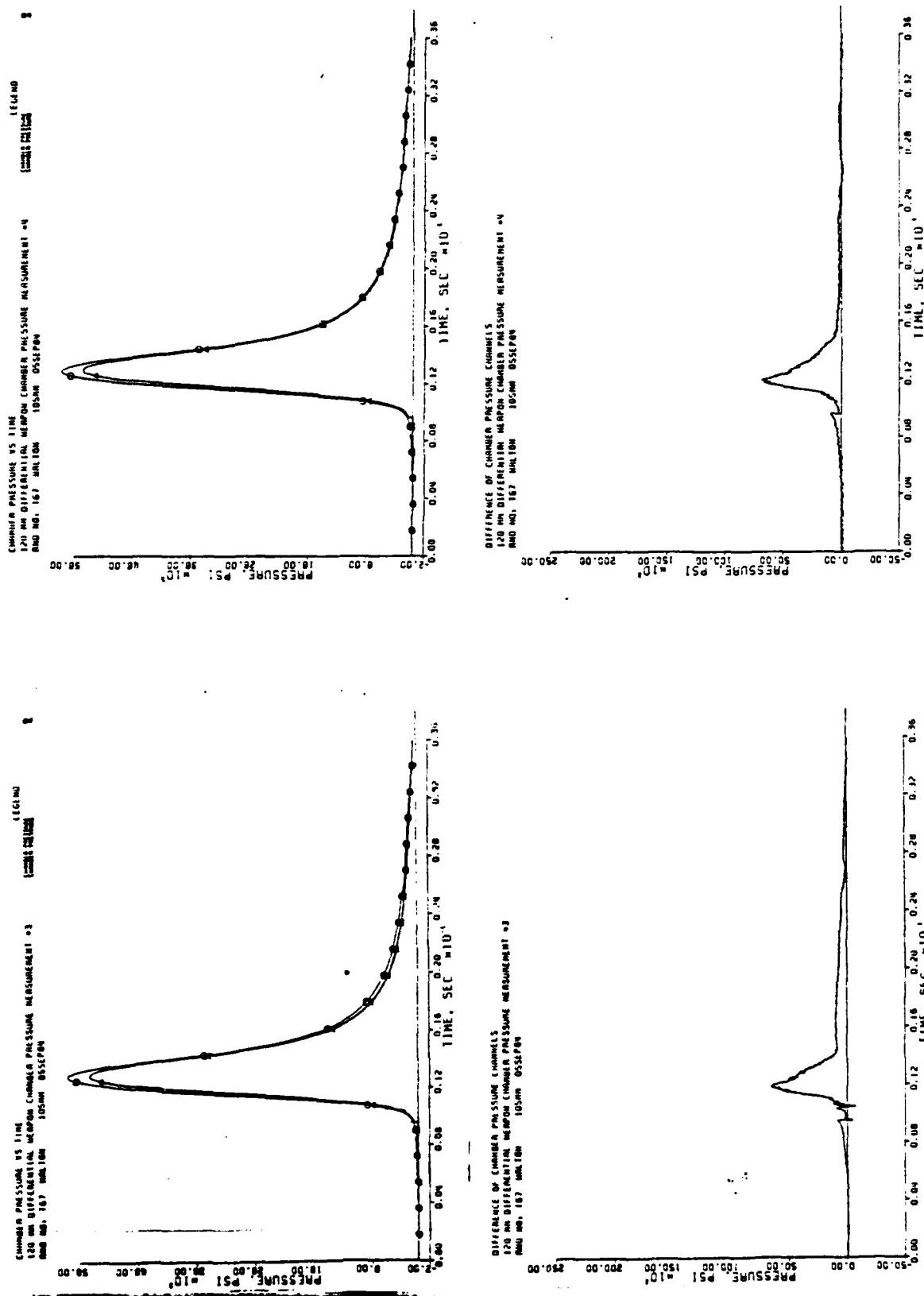


Figure 2.8-1b. Round No. T67.

2.8 (Cont'd)

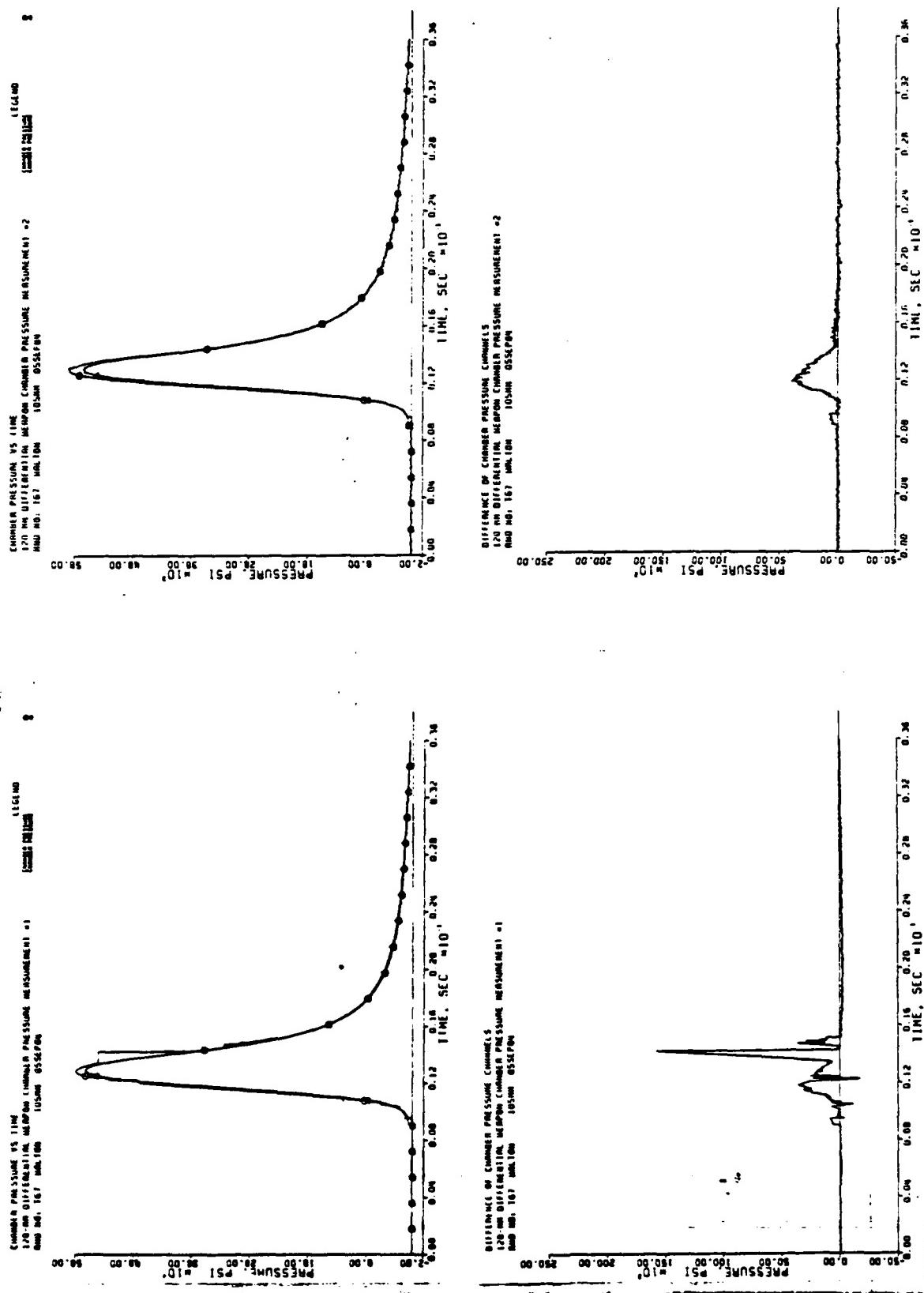


Figure 2.8-1a. — Round No. T67.

MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER

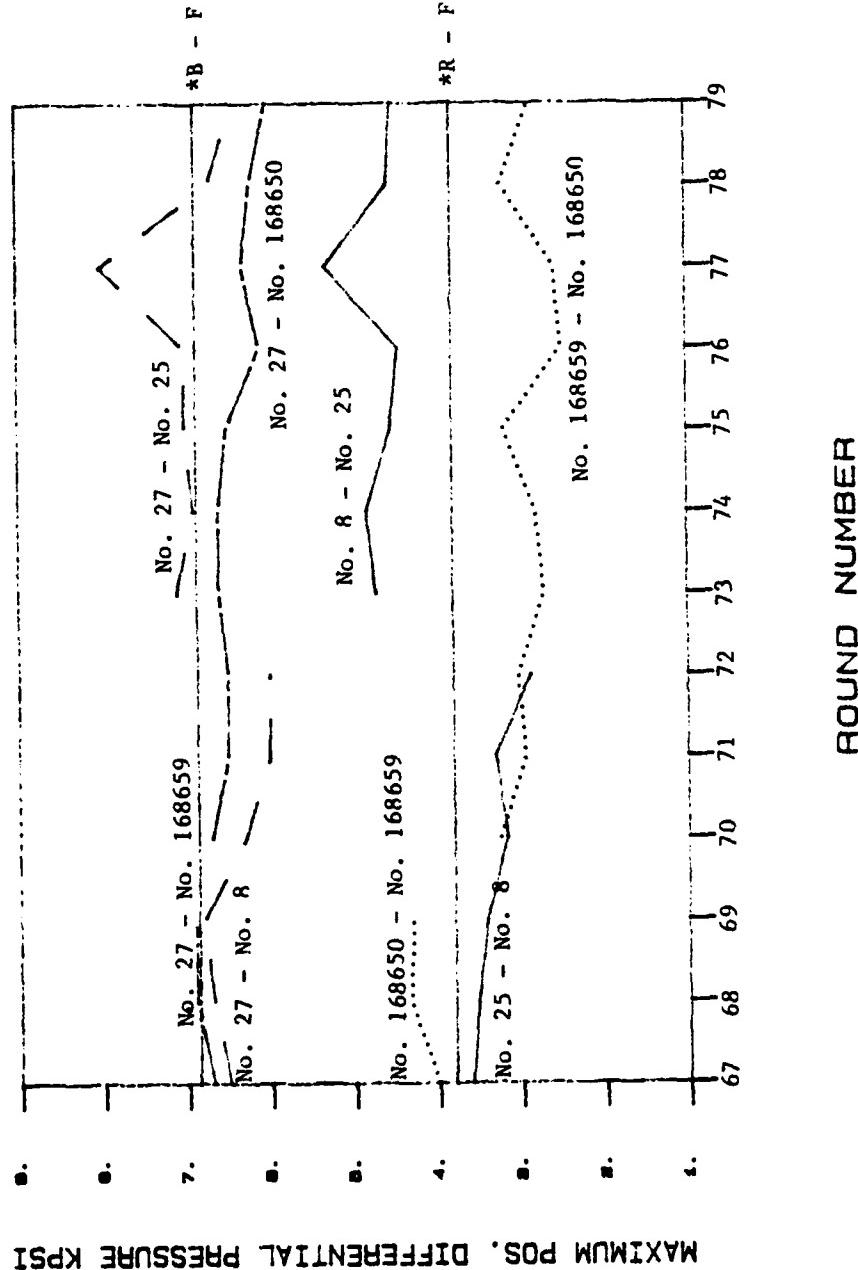


Figure 2.8-1(2). Maximum positive differential pressure.

MAXIMUM CHAMBER PRESSURE VS ROUND NUMBER

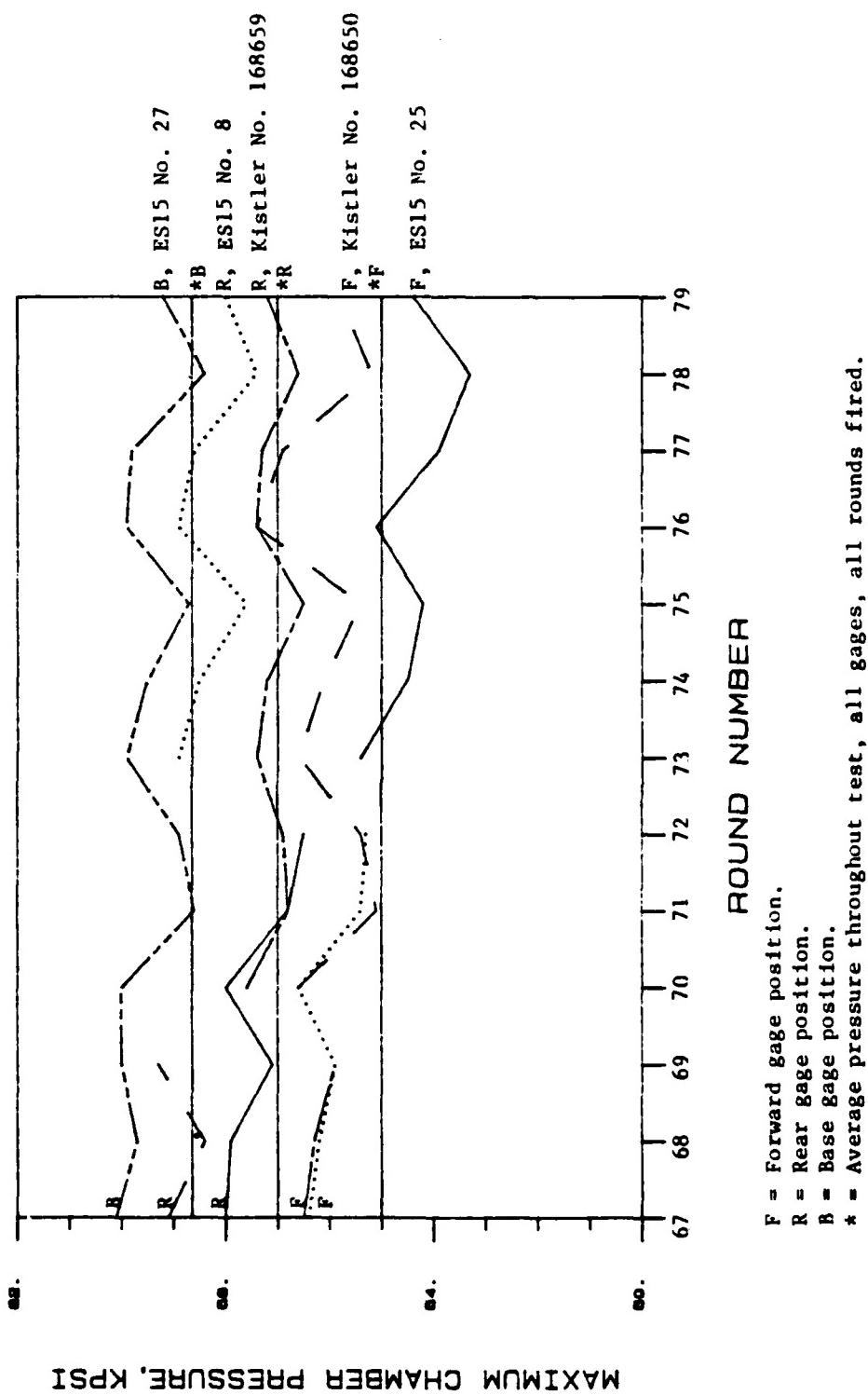


Figure 2.8-1(1). Maximum chamber pressure.

405-mm Tank Gun  
Tube 8W 25151  
Cartridge: M392A2  
Temperature: +70° F  
Date Fired: 5 September 1984

TABLE 2.8-1. CHAMBER PRESSURE DATA - PHASE IIb

Ch = Channel.

## 2.8 PHASE IIb. ROUNDS 67 THROUGH 79, TUBE 25151

Yuma ES15 gages No. 25 and 8 were mounted in the right side of the tube. This phase was started with 316 charge amplifiers, and was concluded with 504 amplifiers. Kistler gages 168650 and 168659 were mounted in the left side of the tube. These have proven to be good gages throughout the test. Precision Filters 316 charge amplifiers were used in the beginning of the test phase, and Kistler 504 charge amplifiers were used at the end of the phase.

The most notable feature of the first six rounds fired with the ES15 gages is the variety of problems associated with the return to zero on the differential plots. The first differential plot, round 67, has some cable or connector separation, but otherwise returns to zero baseline in a desirable manner. Round 68 differential plot begins as a positive offset, then decays slowly to zero baseline. Round 69 has a uniform negative offset of more than 20 milliseconds duration. Round 70 is similar to round 68, but as the positive offset decays, the trace passes through zero baseline and becomes negative. Round 71 also decays slowly through zero, then round 72 displays another large negative offset which continues beyond 20 milliseconds duration. Neither the peak pressures or the positive differential peak pressures are obviously out of the expected range.

It is difficult to attribute such performance to gage position and tube stresses on the gage. The gages were not moved until after round 72. The traditional explanation of heat on the gage is the most tempting explanation, but previous results during this test would indicate otherwise. Another explanation may be that the piezoelectric sensing element responds to an increase in pressure in a predictable manner, but as the compression of the element is reduced, the decrease in charge output is not repeatable.

After changing ES15 gage positions, a pronounced positive offset is present on the differential pressure records. However, the offset is now severe and very repeatable, decaying to zero baseline at almost the same rate in each plot. The only change between the first six rounds and the following seven rounds is the gage position. There is a noticeable increase in peak differential pressures immediately after the gage change, suggesting that the large positive offset has an undesirable influence on the differential results.

The Kistler gages perform well until round 70, when the positions are changed. A small negative transient then develops at the end of the positive peak, sometimes increasing in amplitude to the extent of equalling the amplitude of the positive peak. An immediate drop in differential pressure is apparent at round 70. The positive differential peaks are lower than the expected levels, again suggesting that distortion of the final portion of the differential record can serve as a flag for indicating problems with earlier portions of the record.

2.7 (Cont'd)

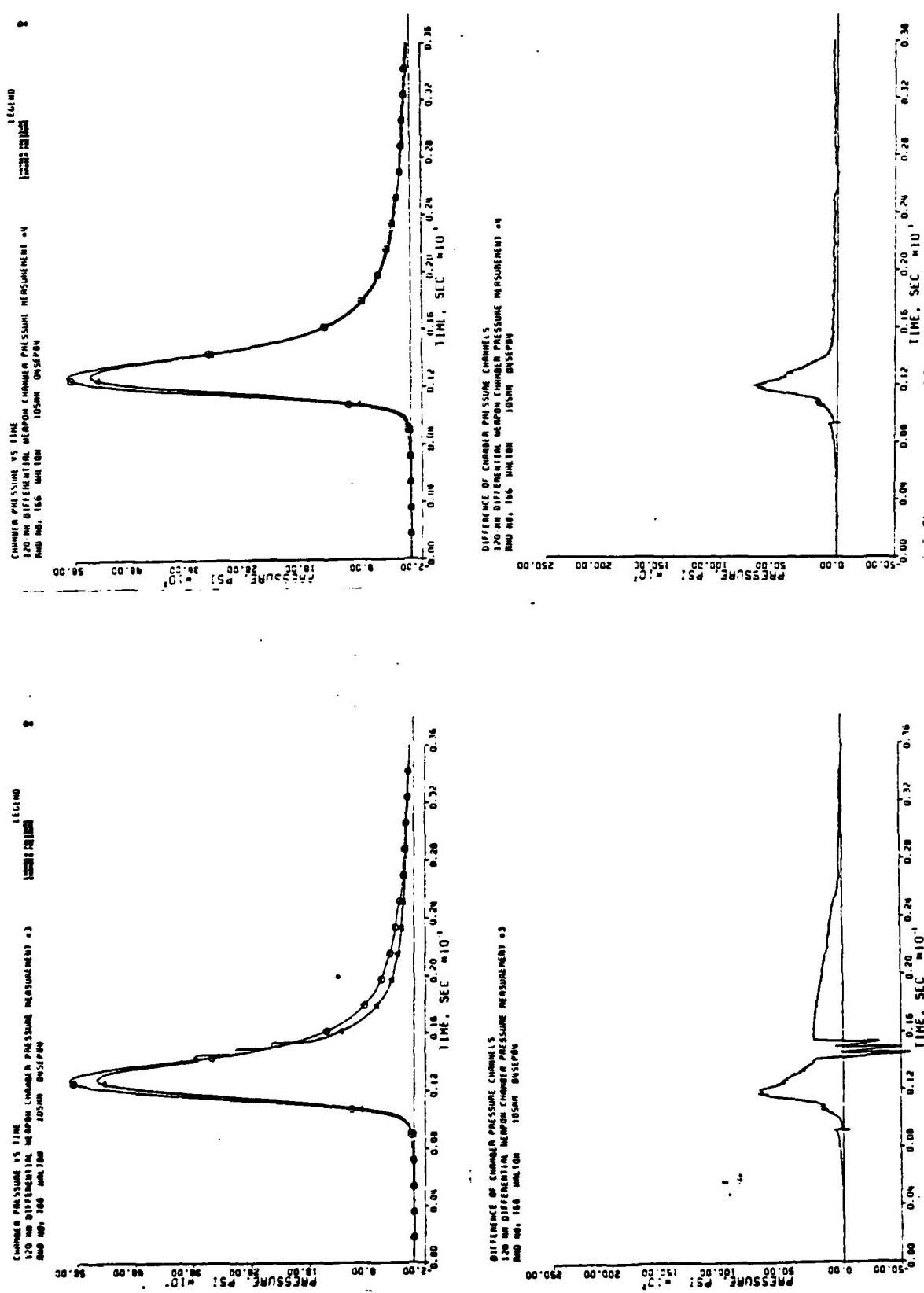


Figure 2.7-6b. Round No. T66.

2.7 (Cont'd)

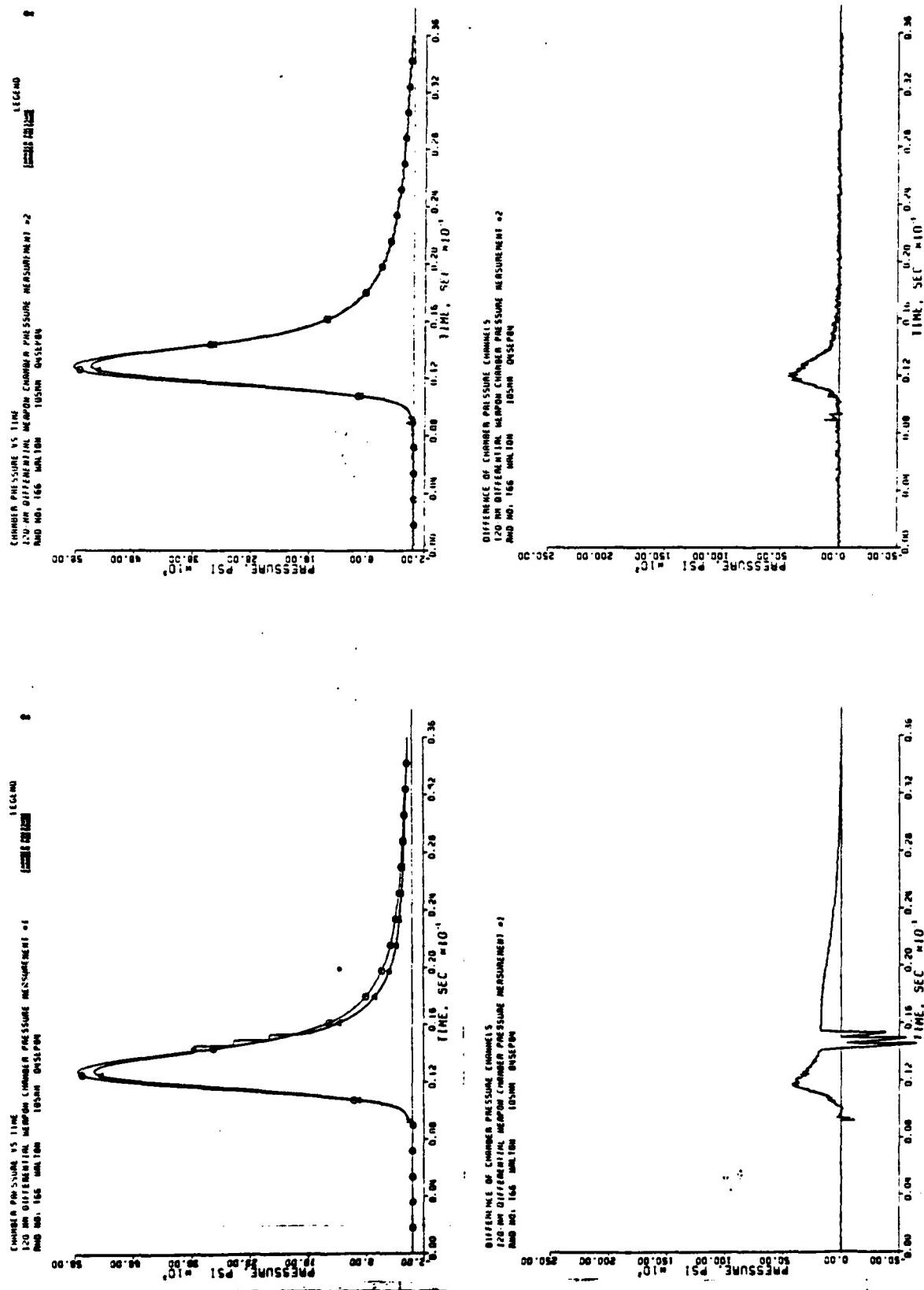


Figure 2.7-6a. Round No. T66.

2.7 (Cont'd)

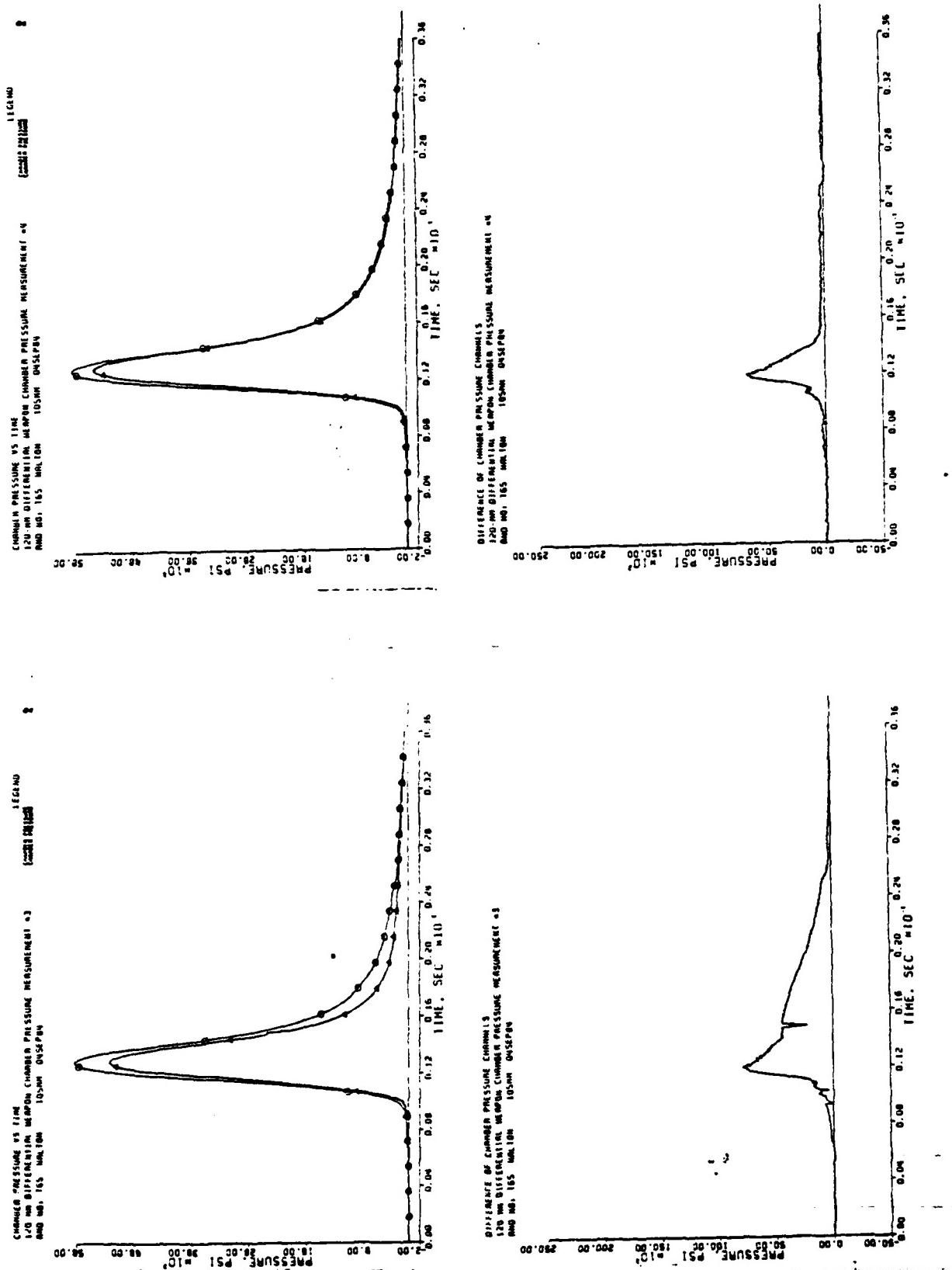


Figure 2.7-5b. Round No. T65.

2.7 (Cont'd)

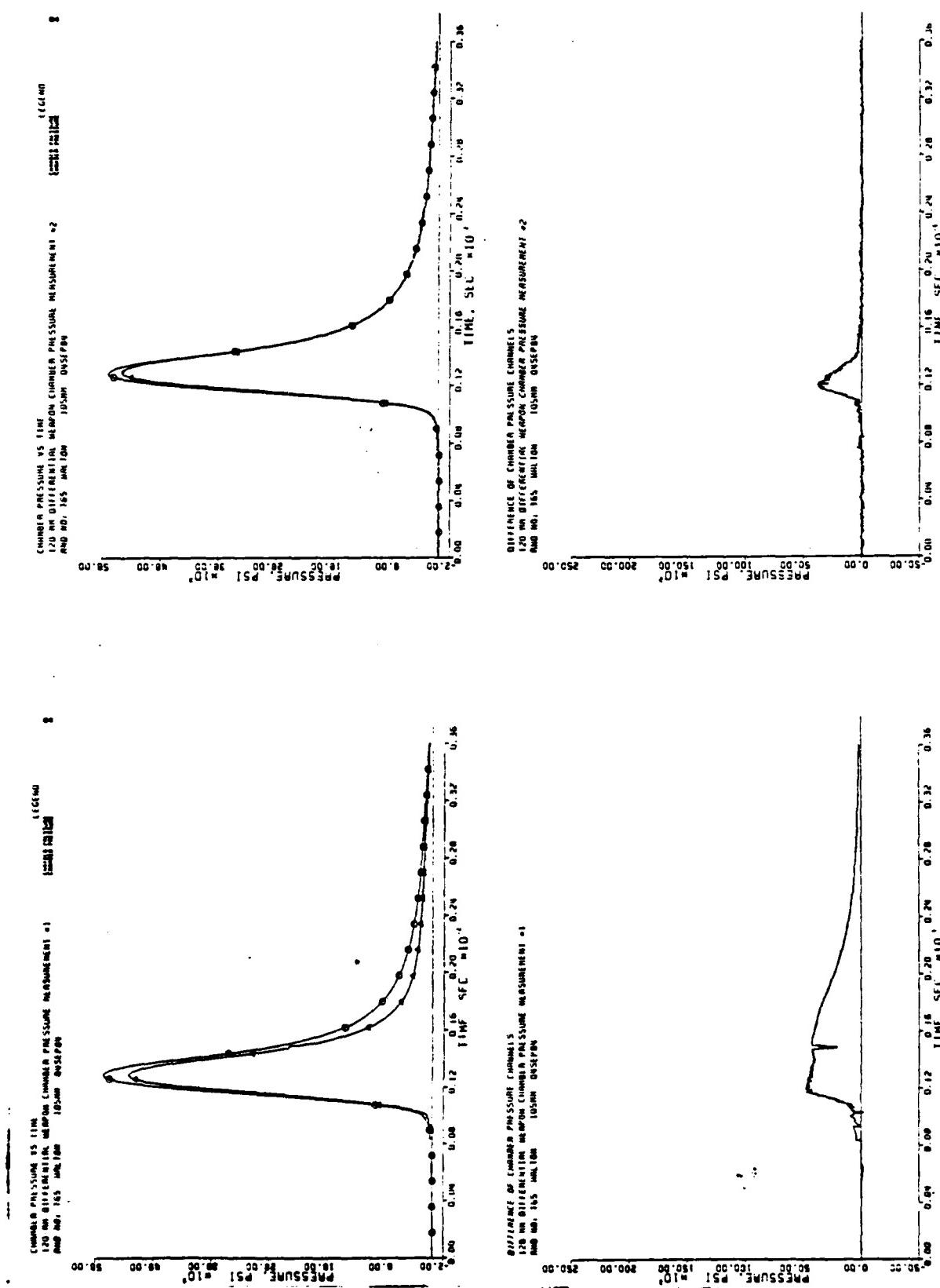


Figure 2.7-5a. Round No. T65.

2.7 (Cont'd)

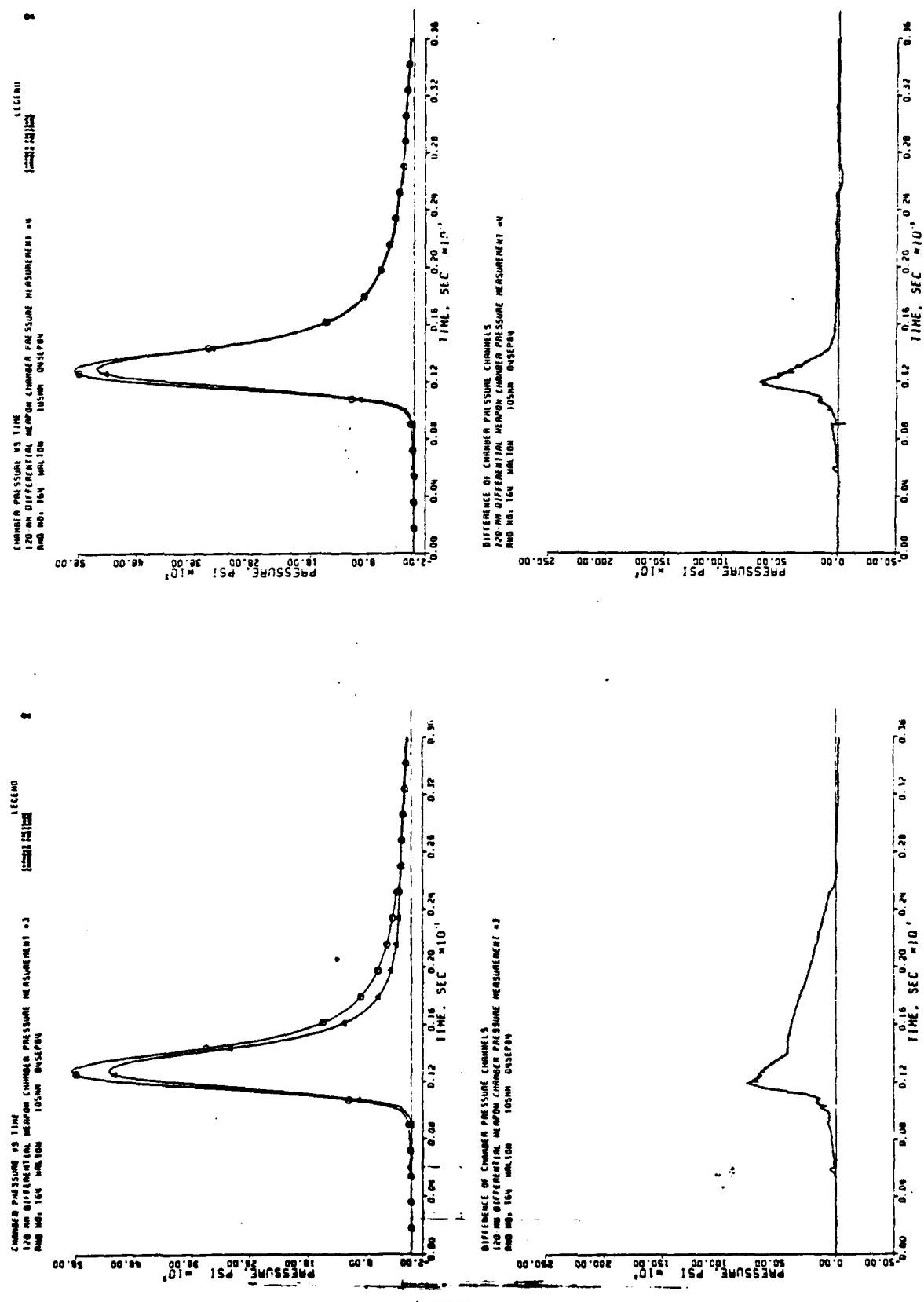


Figure 2.7-4b. Round No. T64.

2.8 (Cont'd)

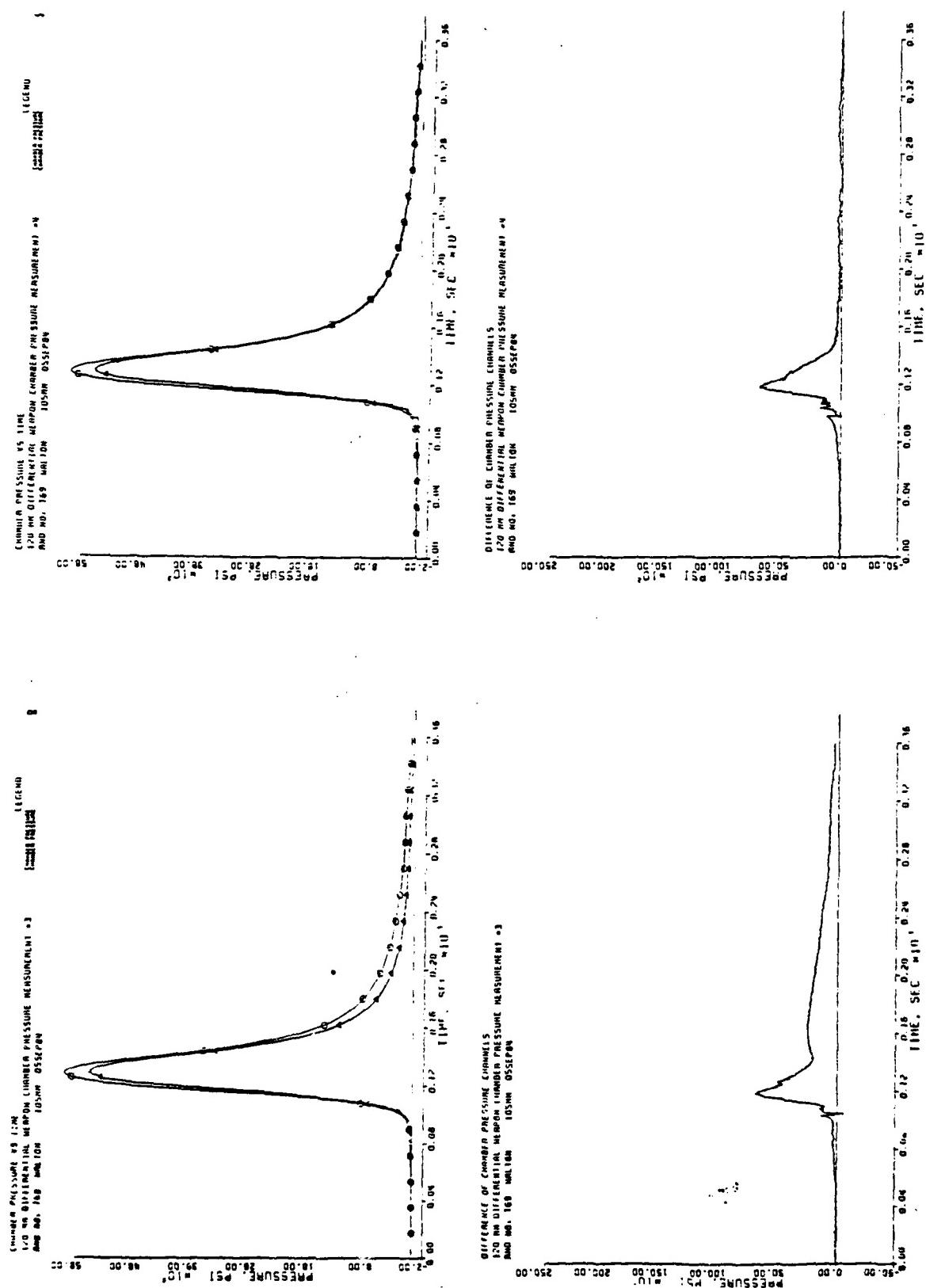


Figure 2.8-3b. Round No. T69.

2.8 (Cont'd)

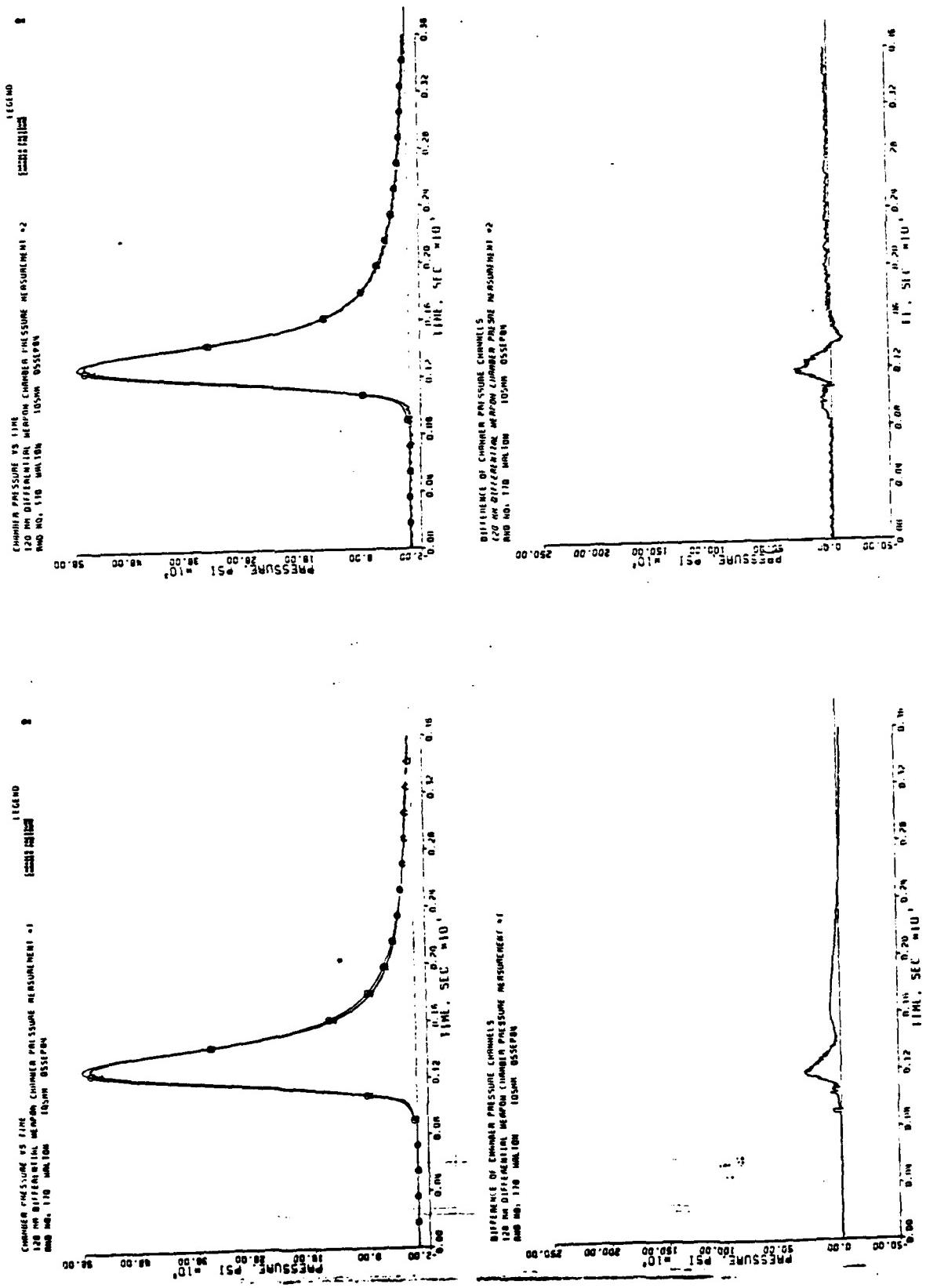


Figure 2.8-4a. Round No. T70.

2.8 (Cont'd)

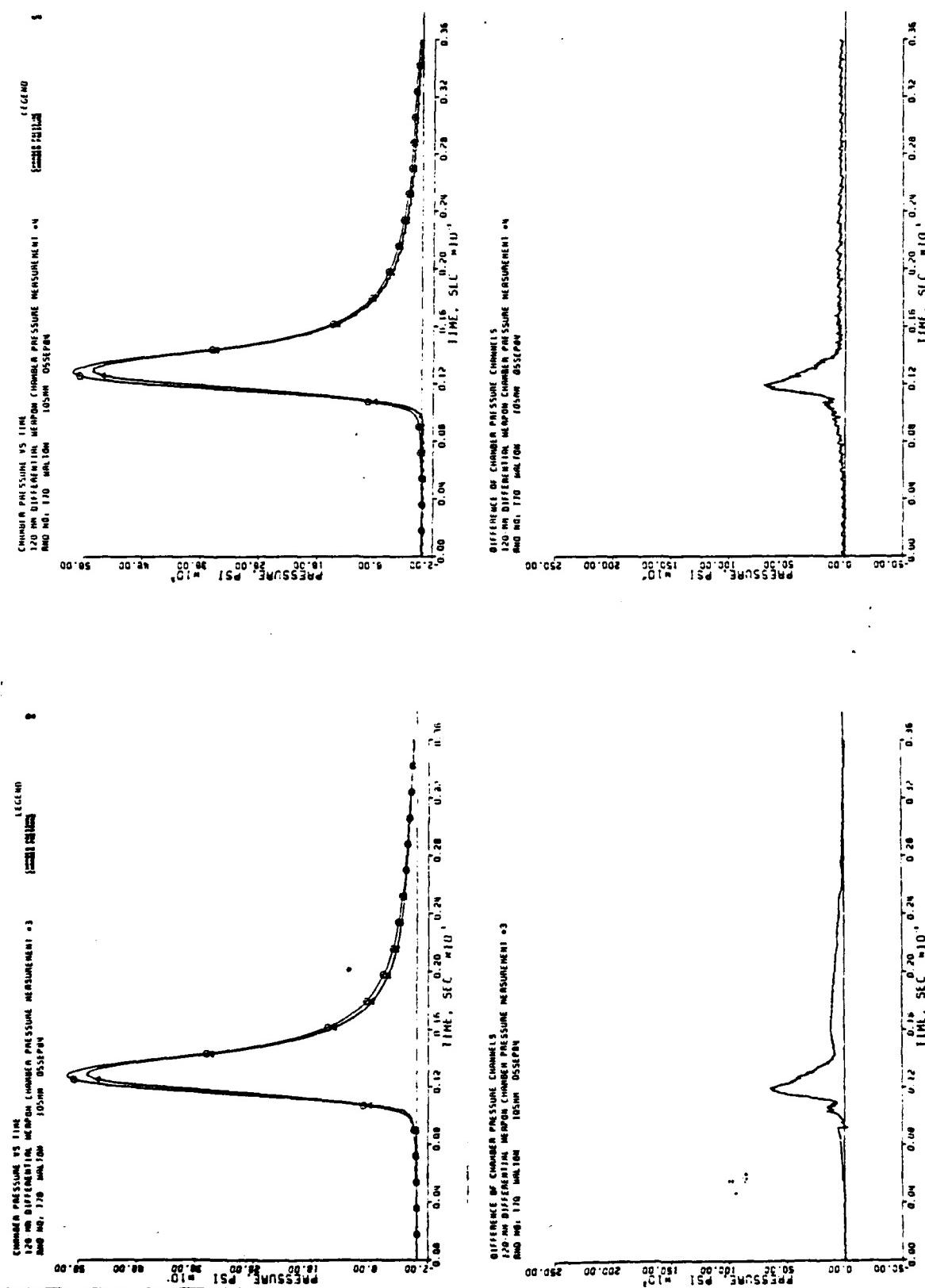


Figure 2.8-4b. Round No. T70.

2.8 (Cont'd)

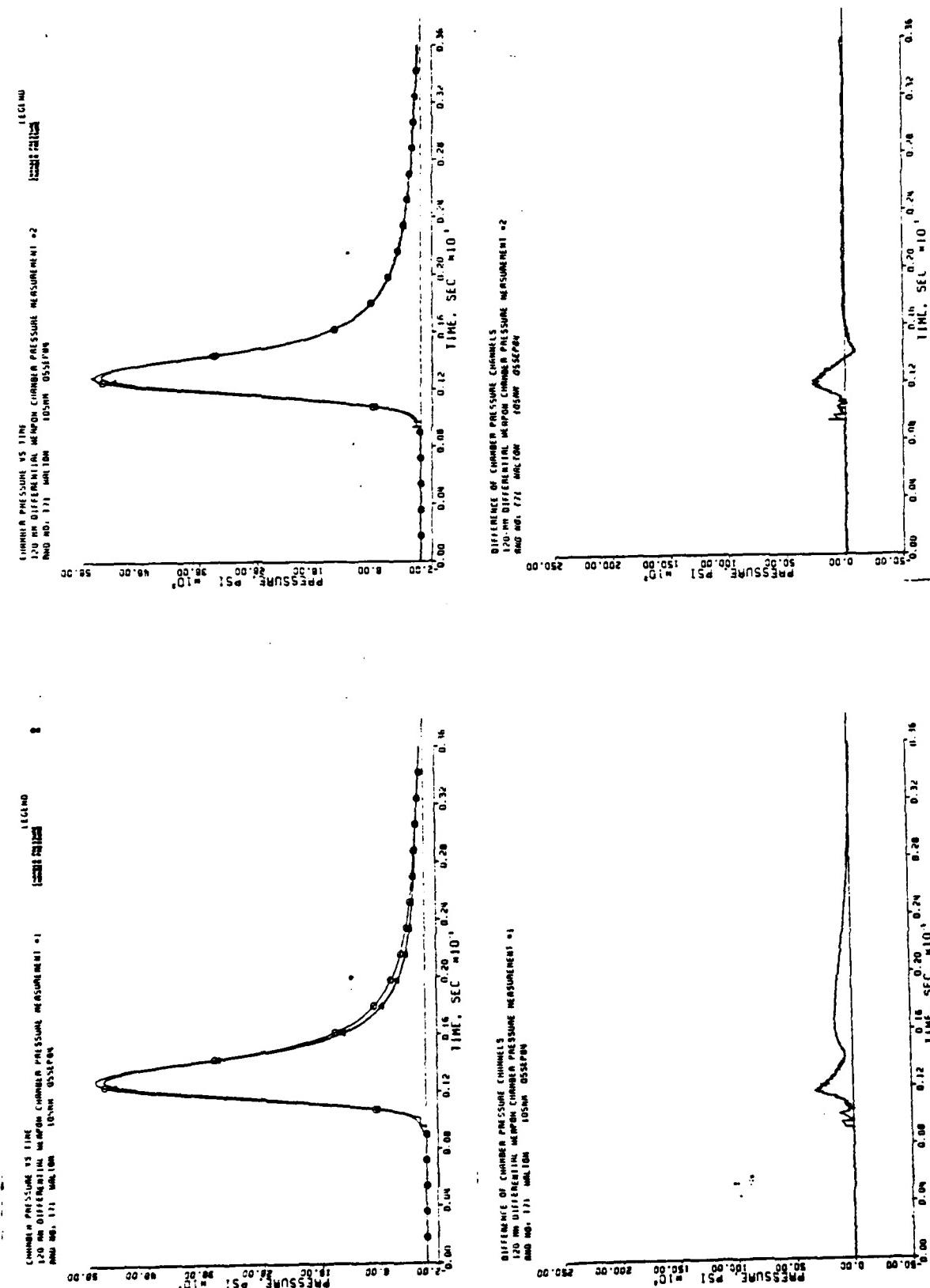


Figure 2.8-5a. Round No. T71.

2.8 (Cont'd)

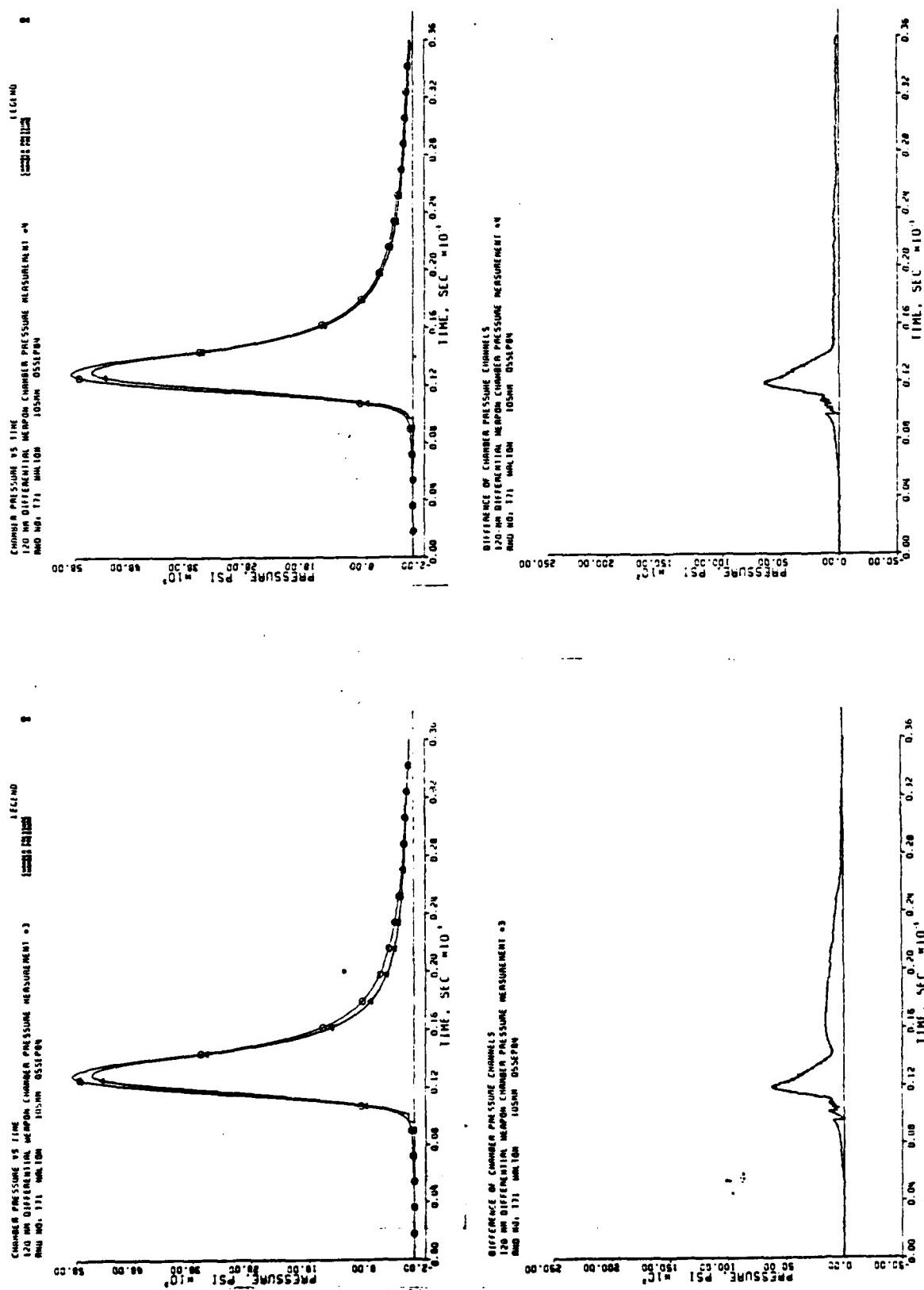


Figure 2.8-5b. Round No. T71.

2.8 (Cont'd)

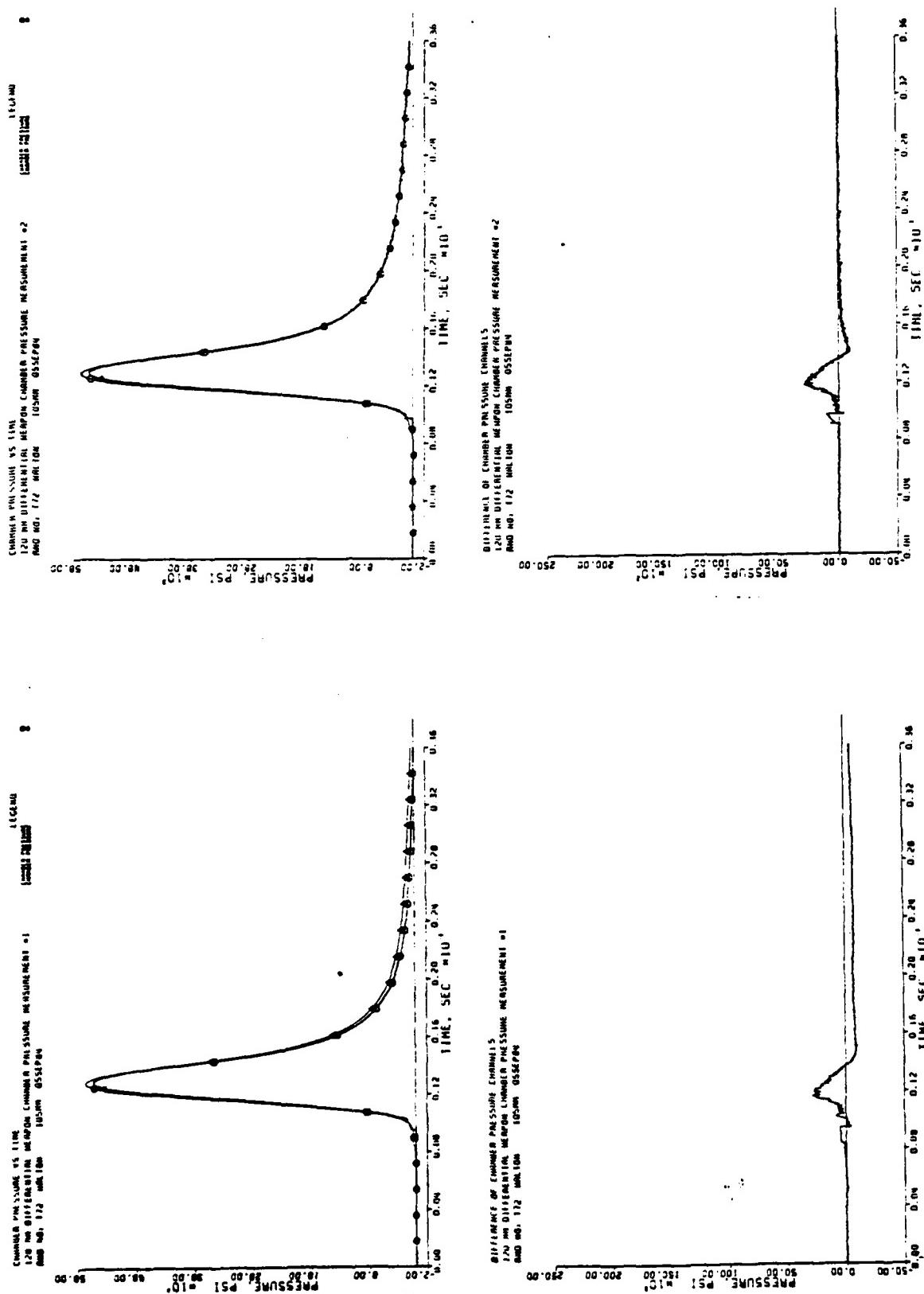


Figure 2.8-6a. Round No. T72.

2.8 (Cont'd)

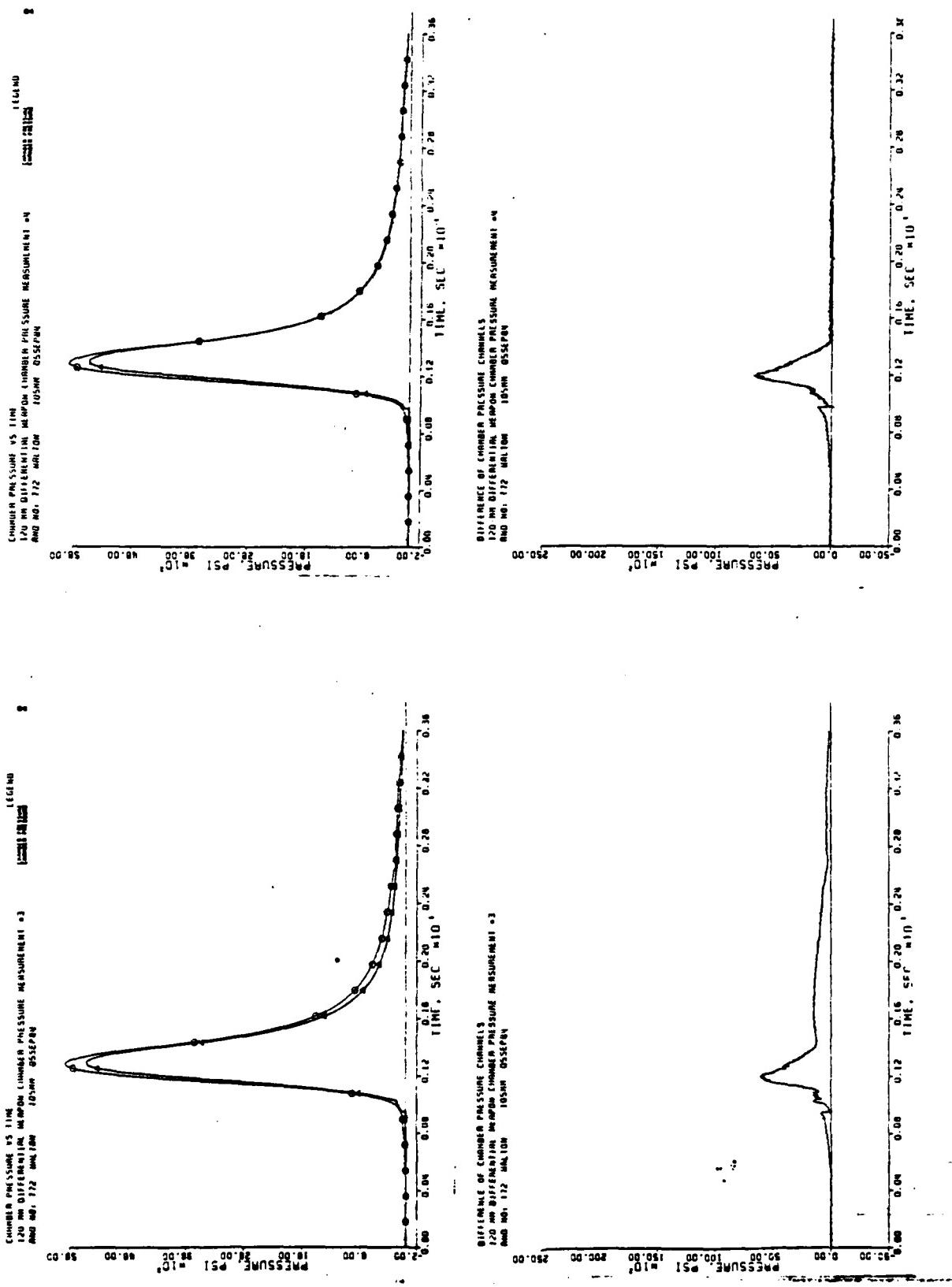


Figure 2.8-6b. Round No. T72.

2.8 (Cont'd)

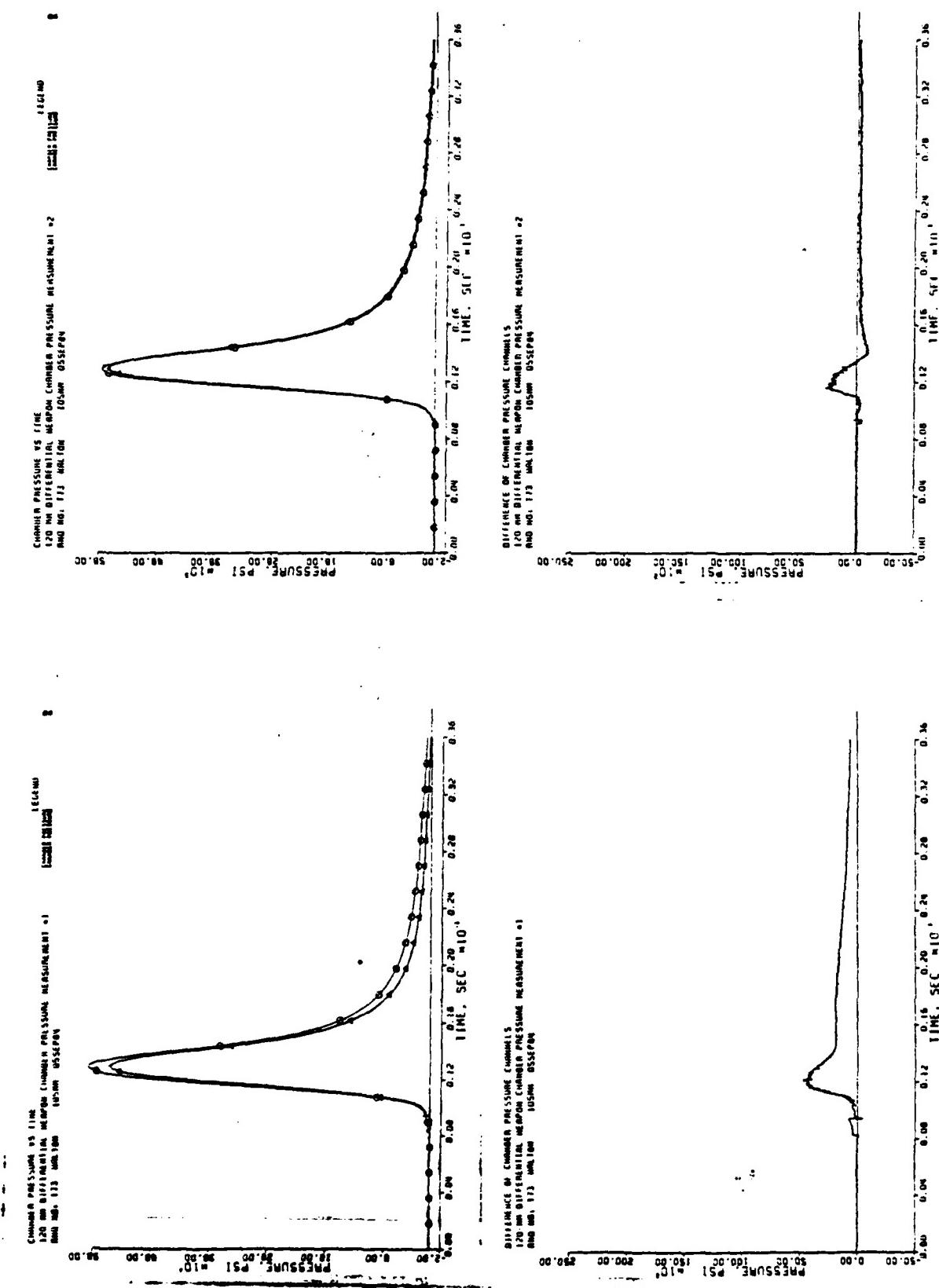


Figure 2.8-7a. Round No. T73.

2.8 (Cont'd)

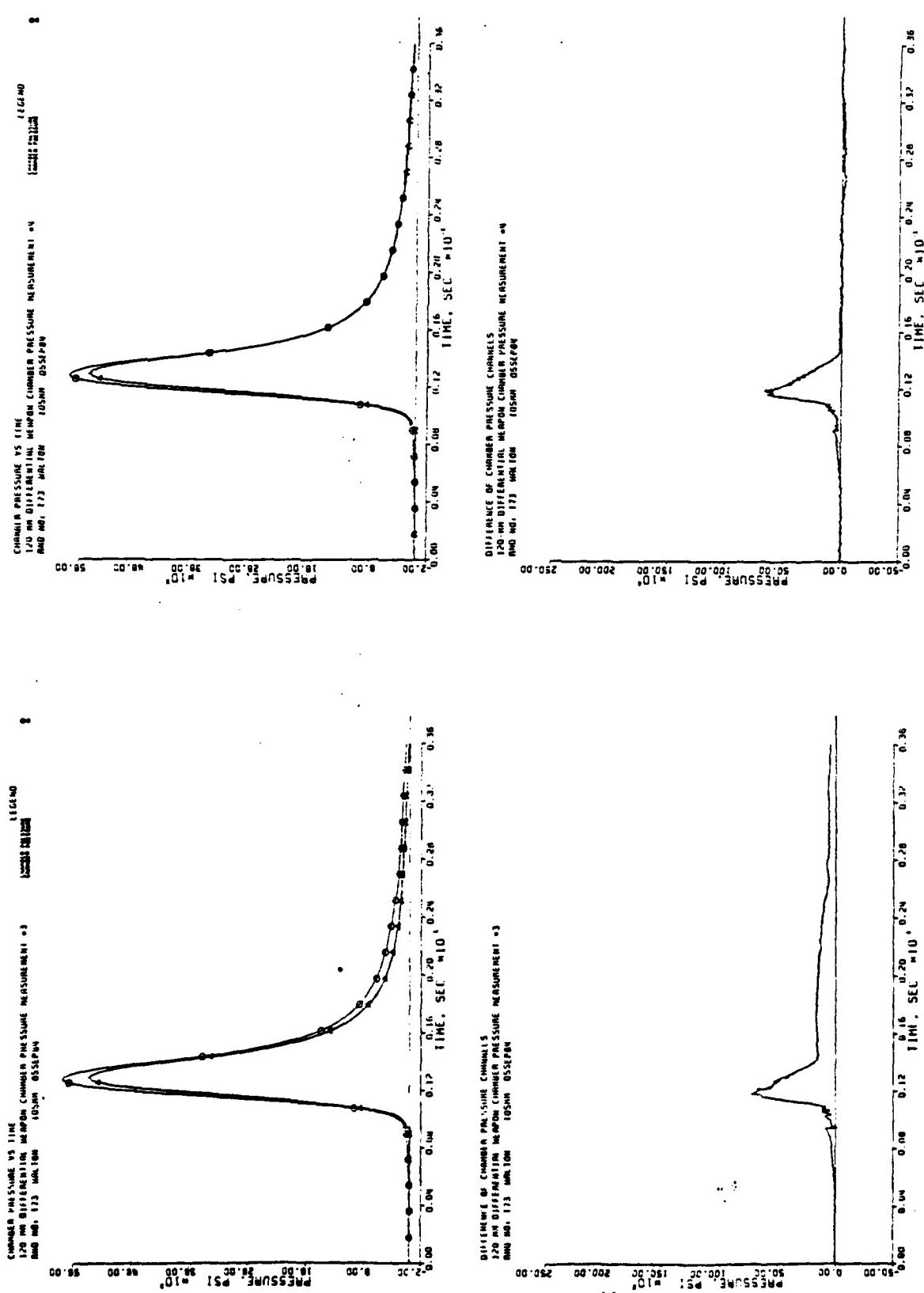


Figure 2.8-7b. Round No. T73.

2.8 (Cont'd)

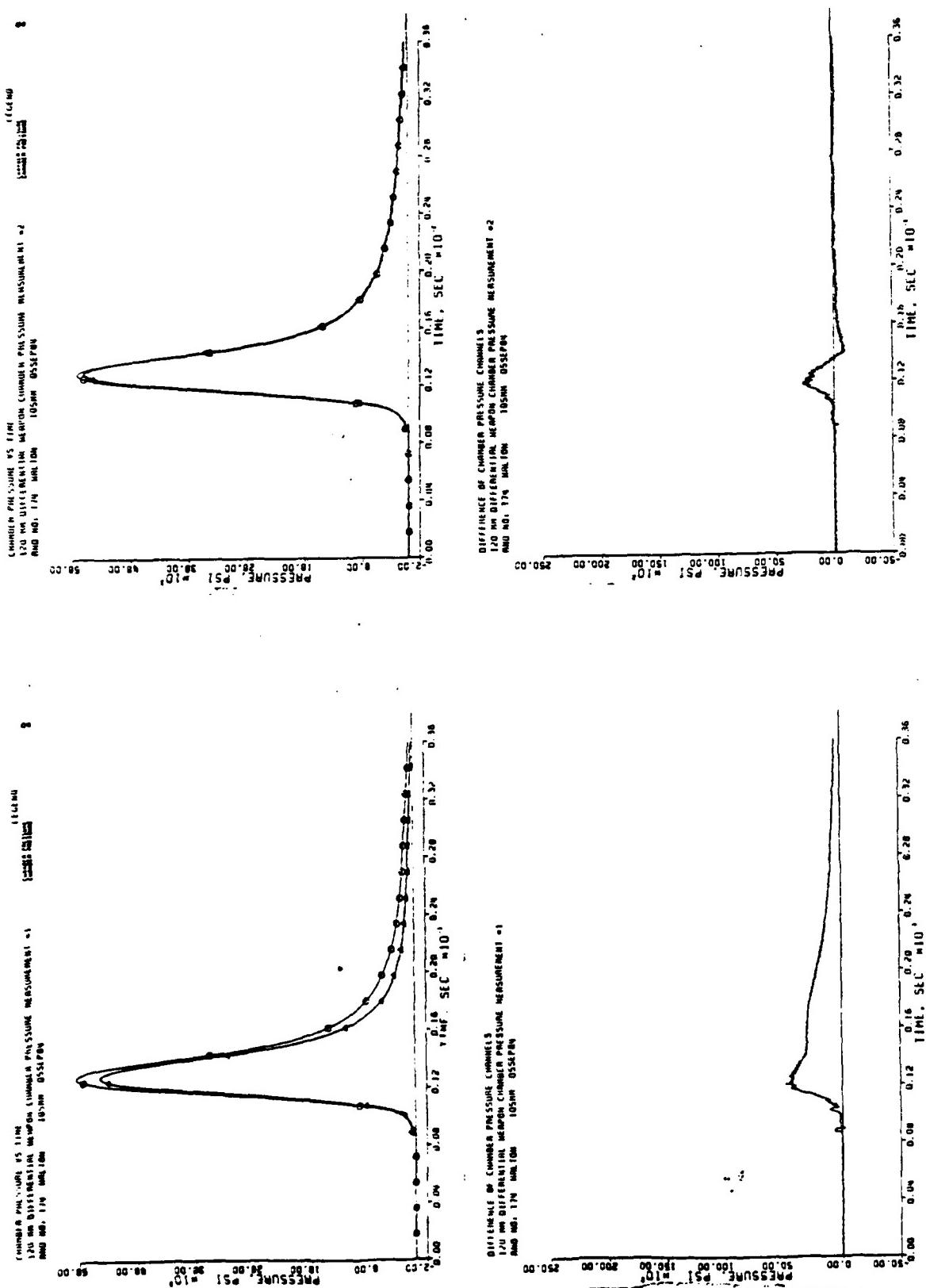


Figure 2.8-8a. Round No. T74.

2.8 (Cont'd)

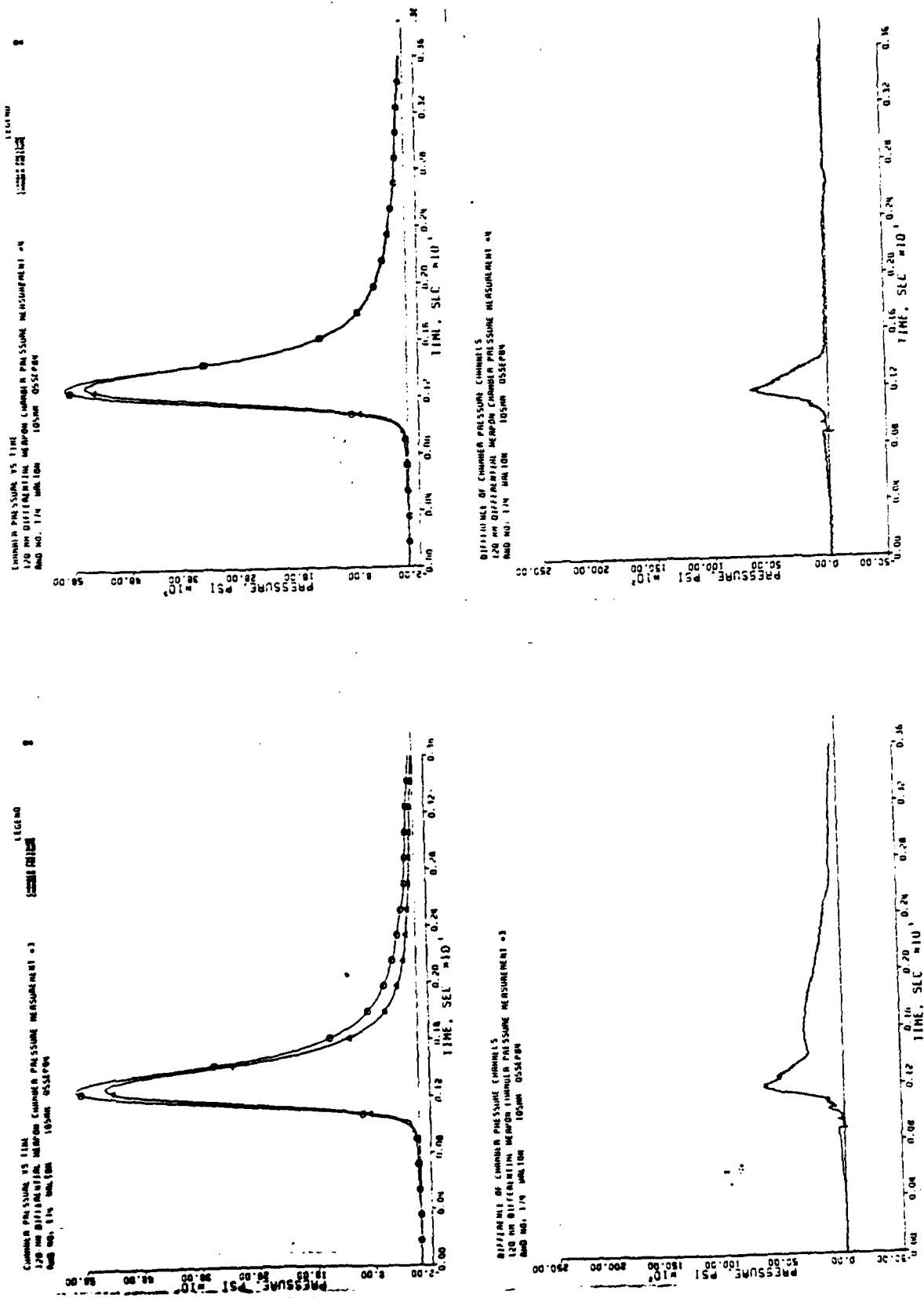


Figure 2.8-8b. Round No. T74.

2.8 (Cont'd)

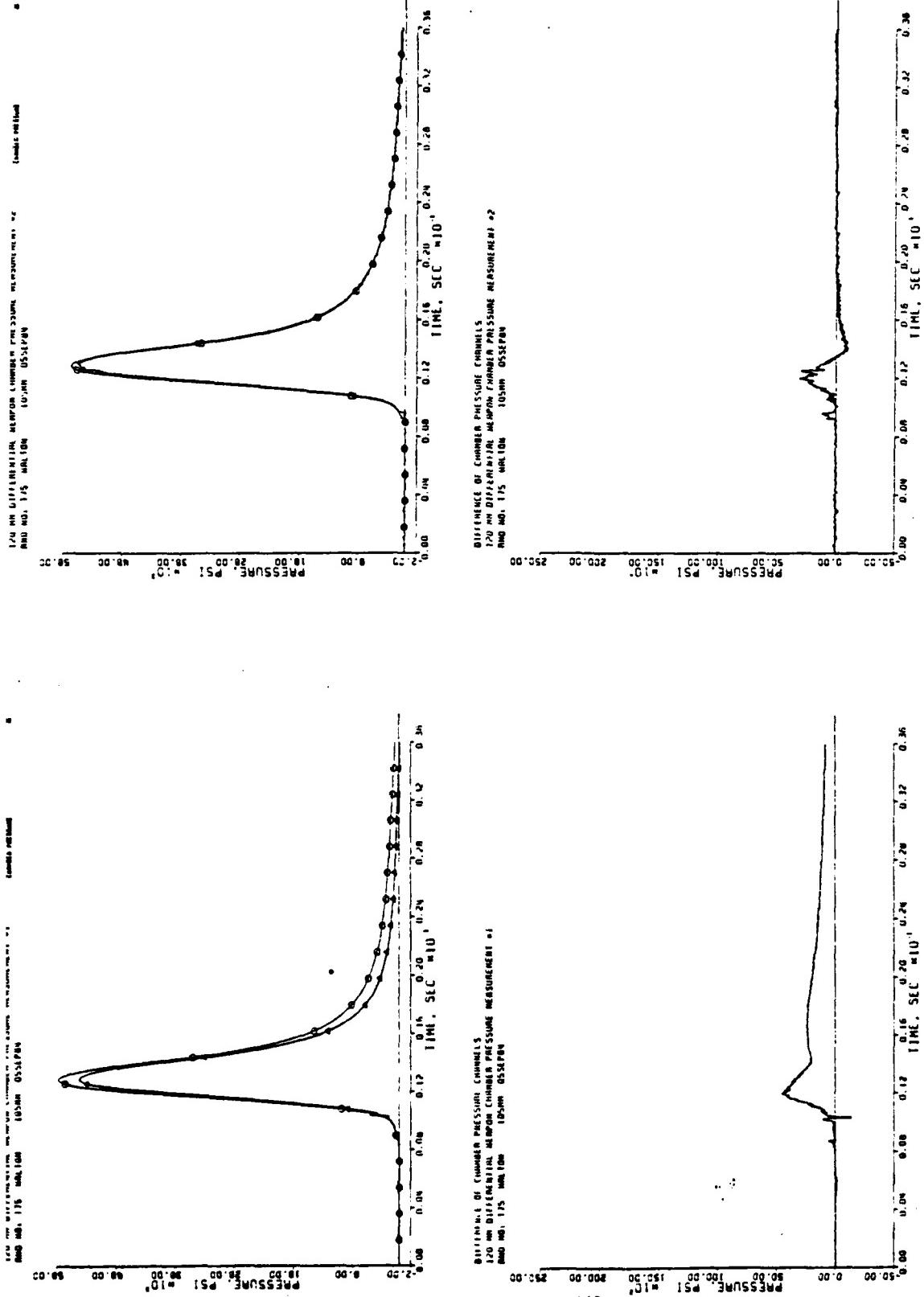
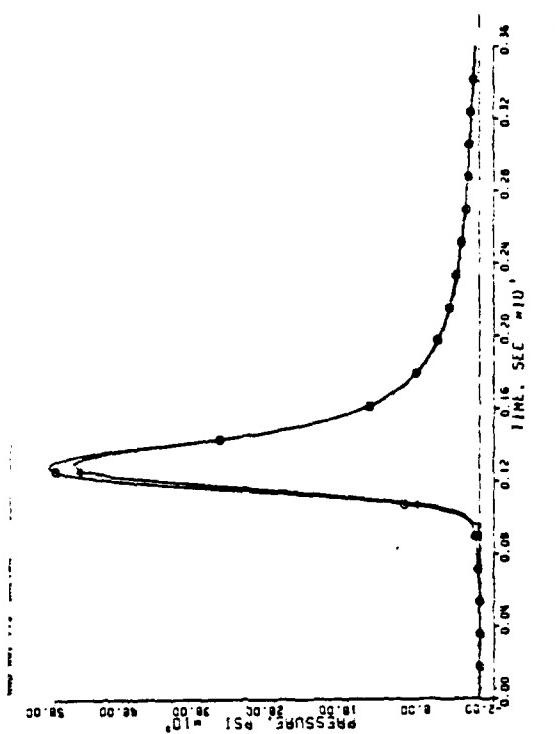


Figure 2.8-9a. Round No. T75.



DIFFERENCE OF CHAMBER PRESSURE CHANNELS  
120 MV DIFFERENTIAL, 100% CHARGE, MEASURED AT  
ROUND NO. T75 MILLION DOLLAR OBSERVATION



DIFFERENCE OF CHAMBER PRESSURE CHANNELS  
120 MV DIFFERENTIAL, 100% CHARGE, MEASURED AT  
ROUND NO. T75 MILLION DOLLAR OBSERVATION

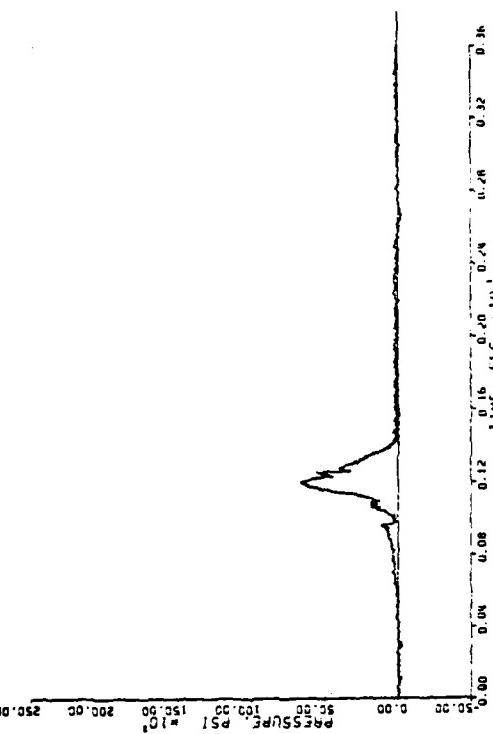


Figure 2.8-9b. Round No. T75.

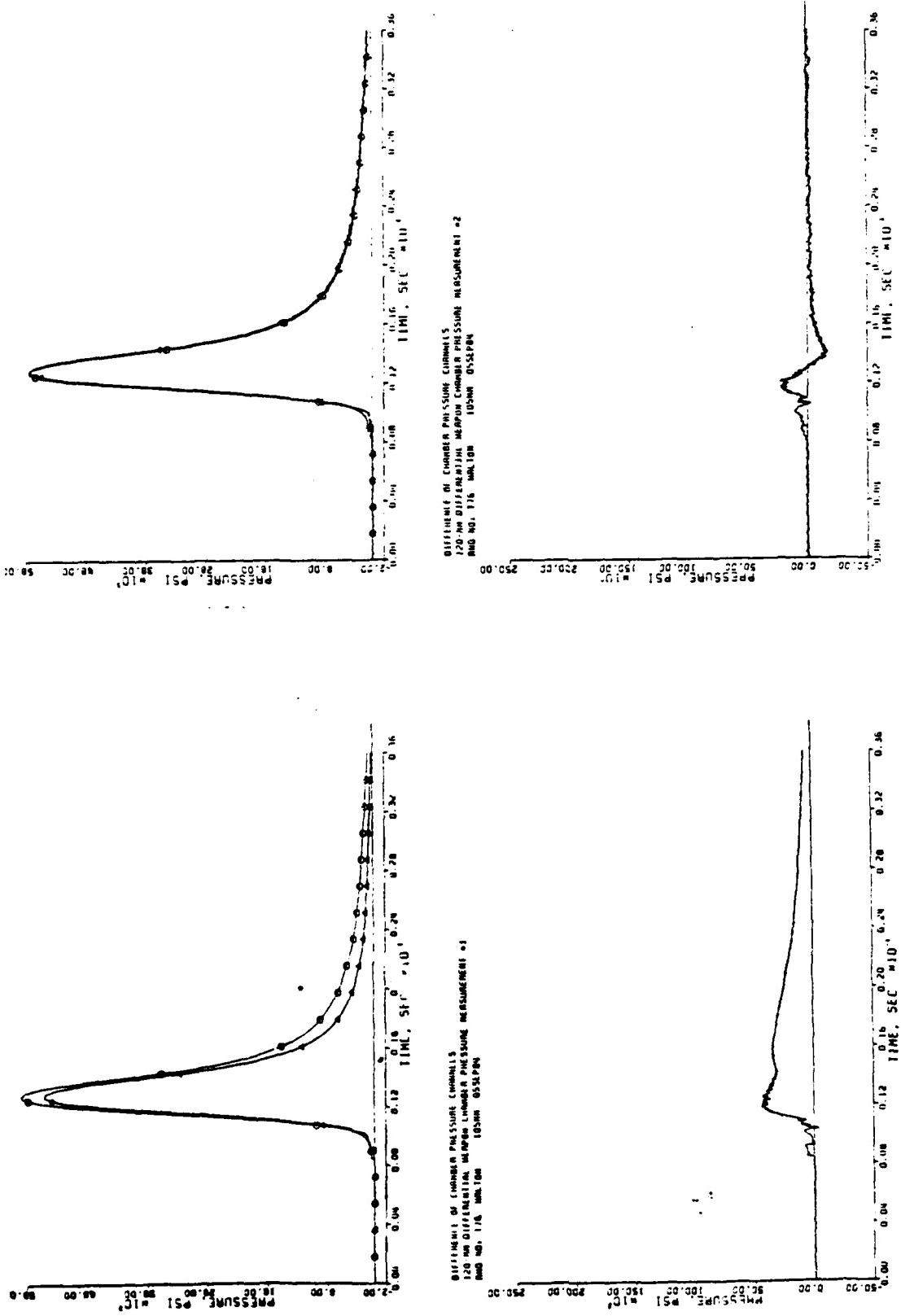


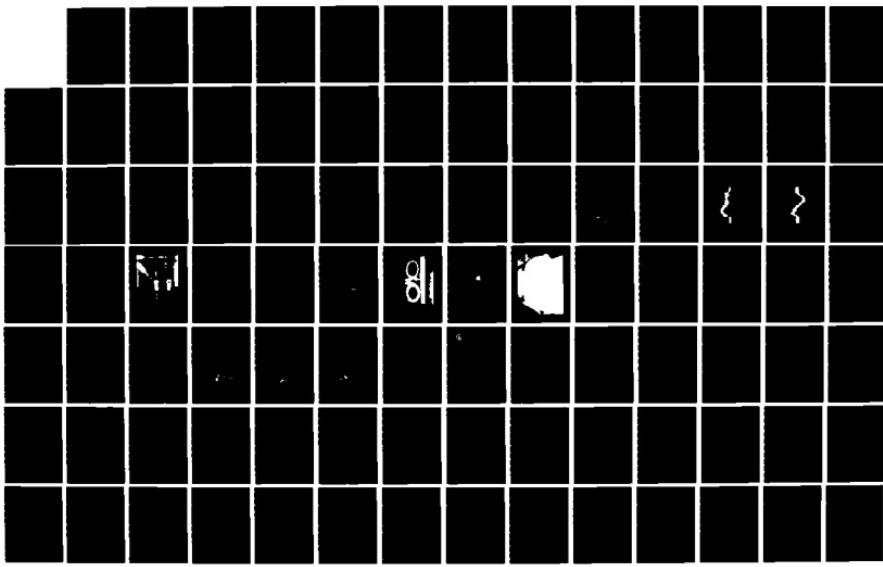
Figure 2.8-10a. Round No. T76.

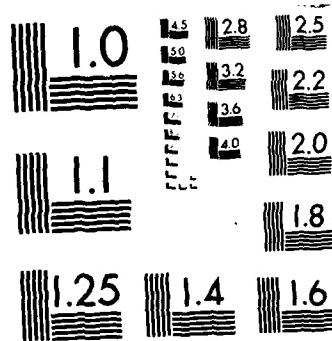
RD-R156 775    METHODOLOGY INVESTIGATION OF 120-MM DIFFERENTIAL WEAPON    3/4  
CHAMBER PRESSURE MEASUREMENT(U) ARMY COMBAT SYSTEMS  
TEST ACTIVITY (PROV) ABERDEEN PROVING GRO.

UNCLASSIFIED    V A BETZOLD ET AL. FEB 85 USACSTA-6163

F/G 14/2

NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS 1963-A

2.8 (Cont'd)

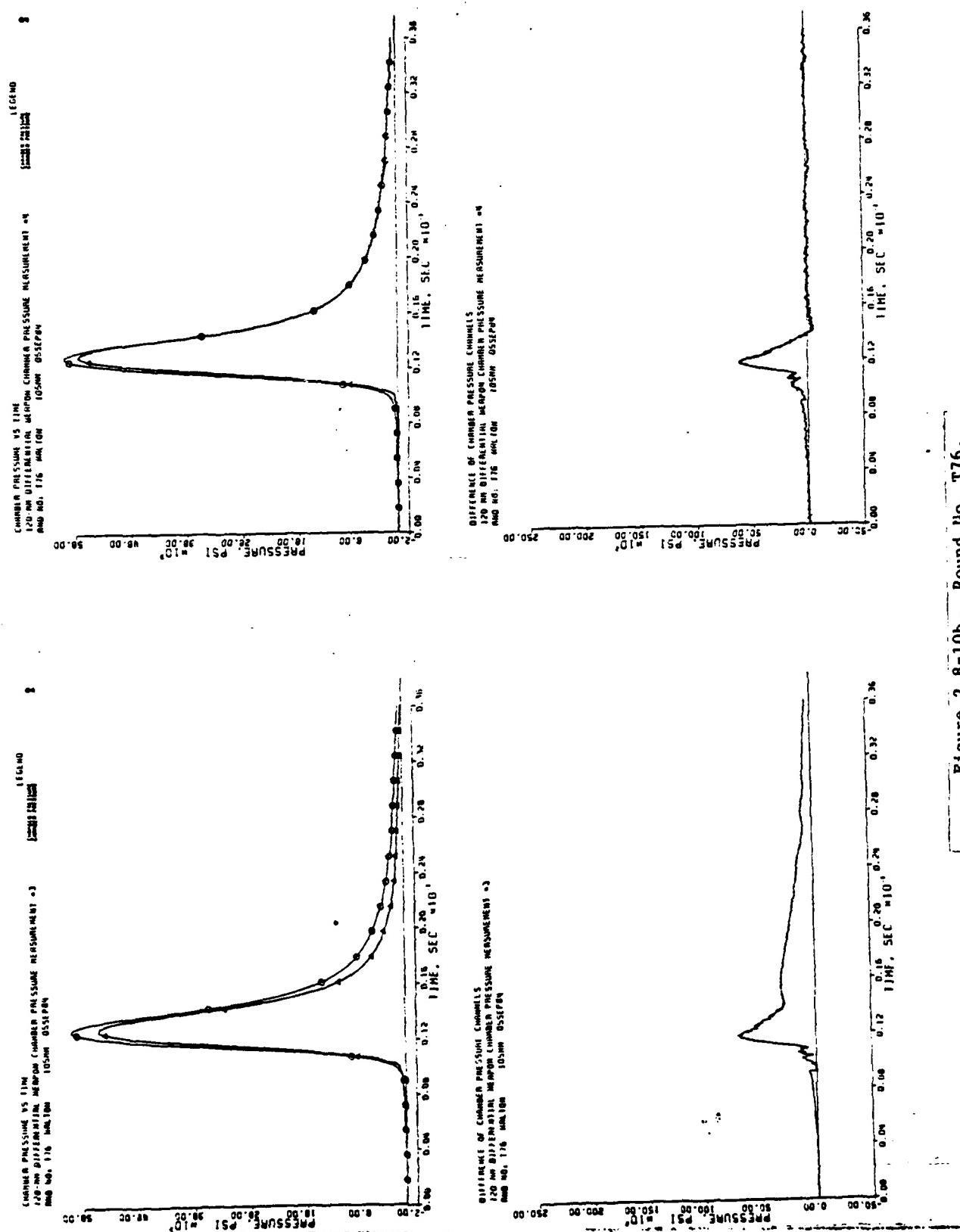


Figure 2.8-10b. Round No. T76.

2.8 (Cont'd)

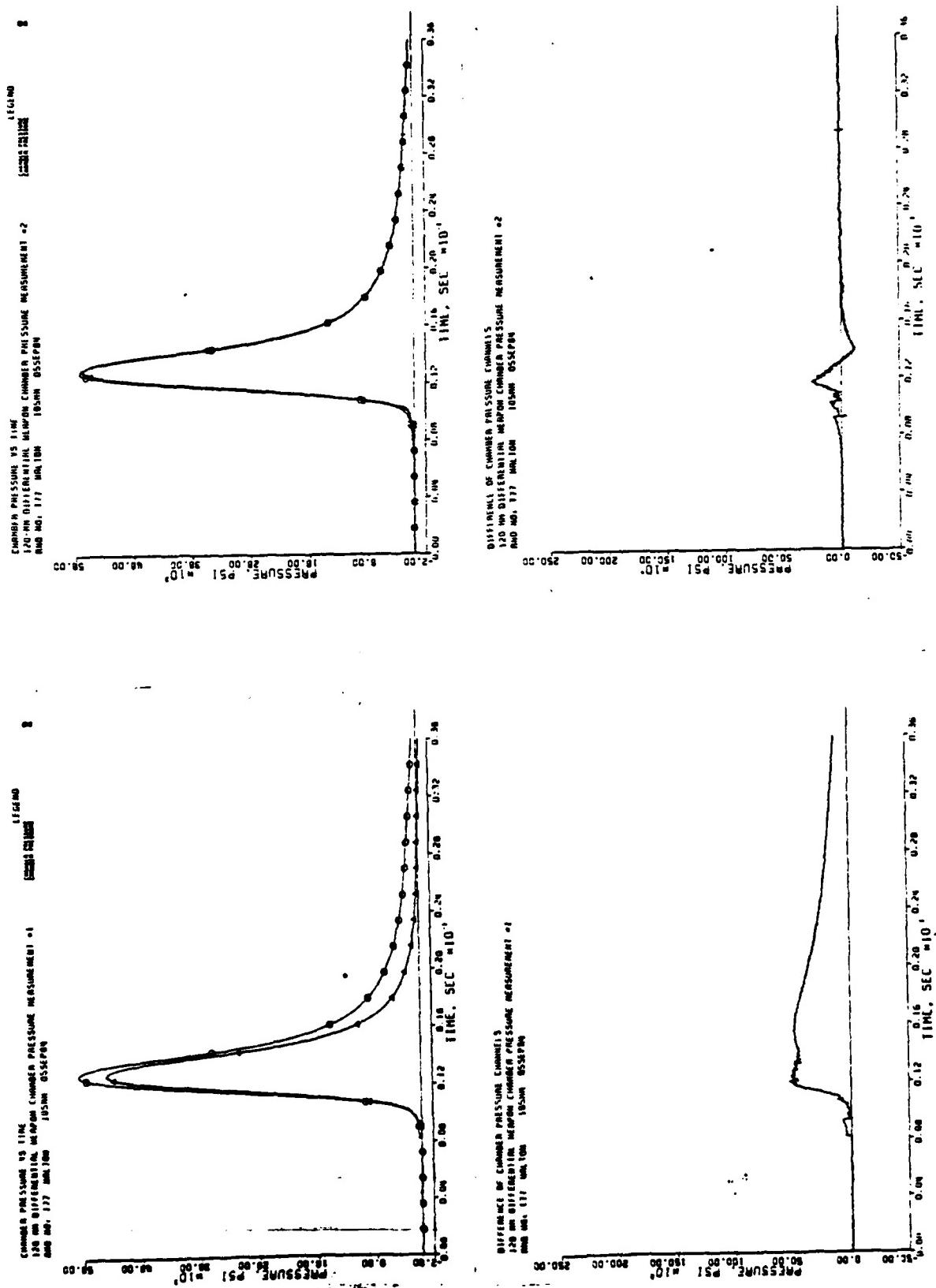


Figure 2.8-11a. Round No. T77.

2.8 (Cont'd)

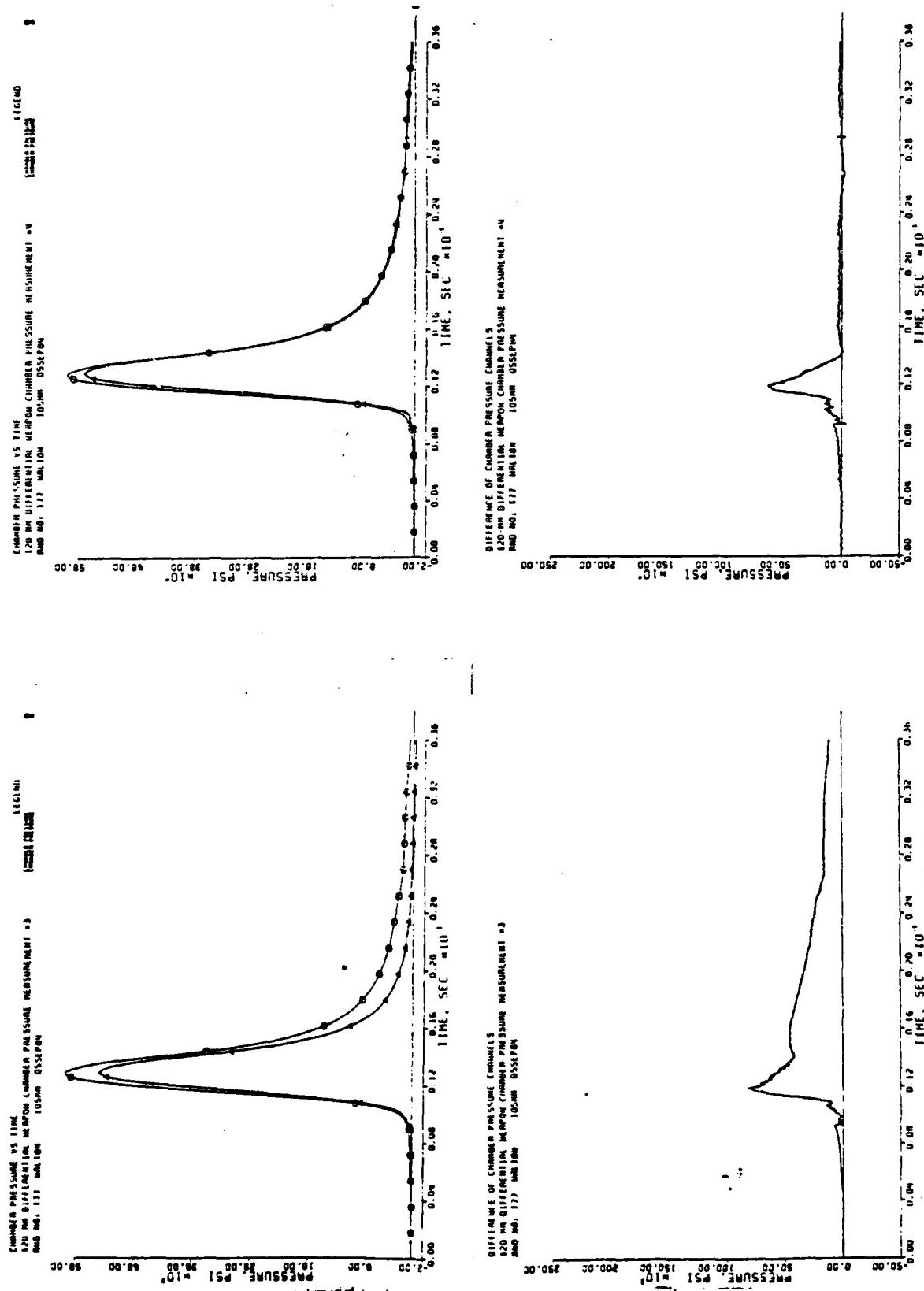


Figure 2.8-11b. Round No. T77.

2.8 (Cont'd)

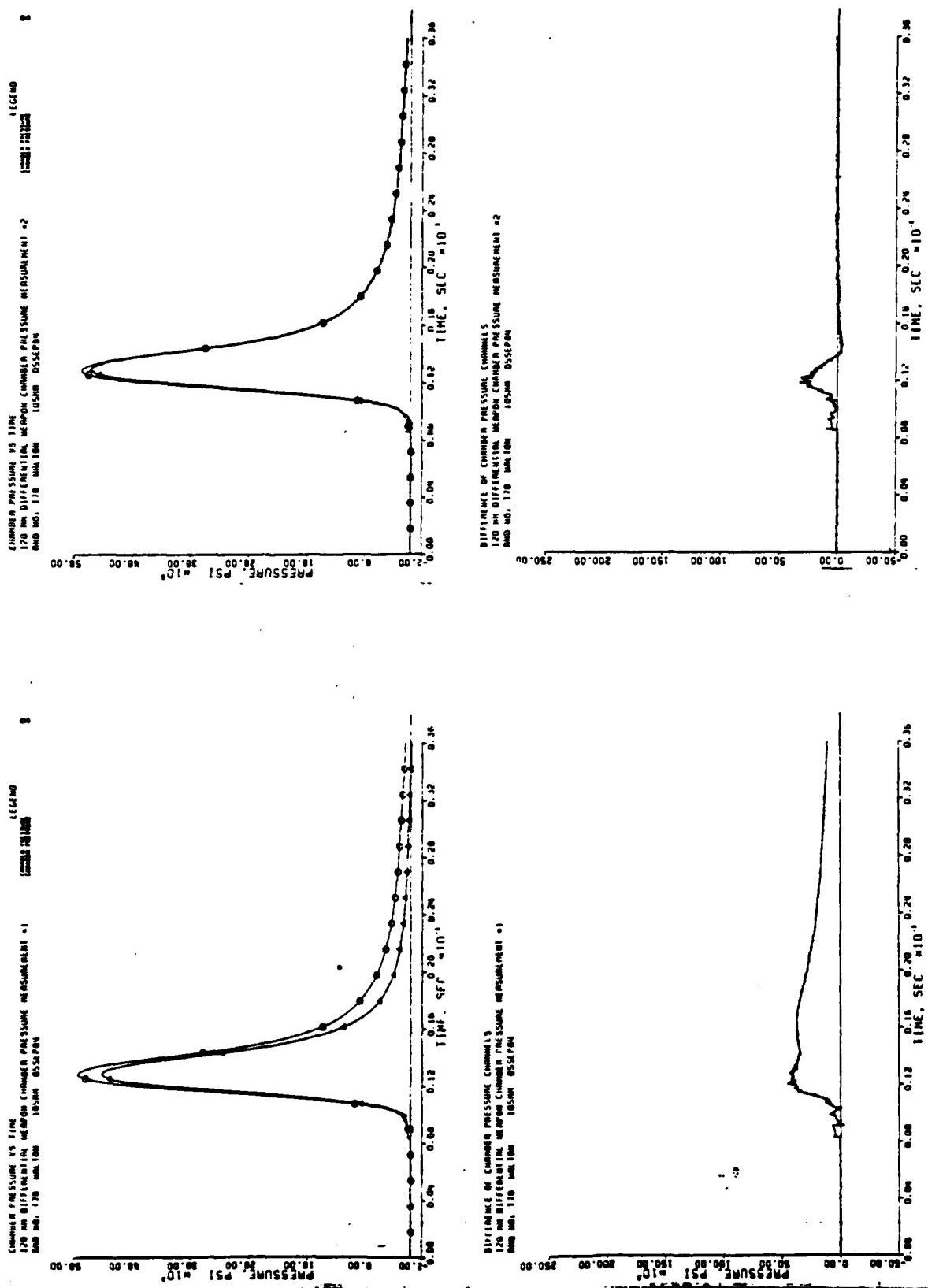


Figure 2.8-12a. Round No. T78.

2.8 (Cont'd)

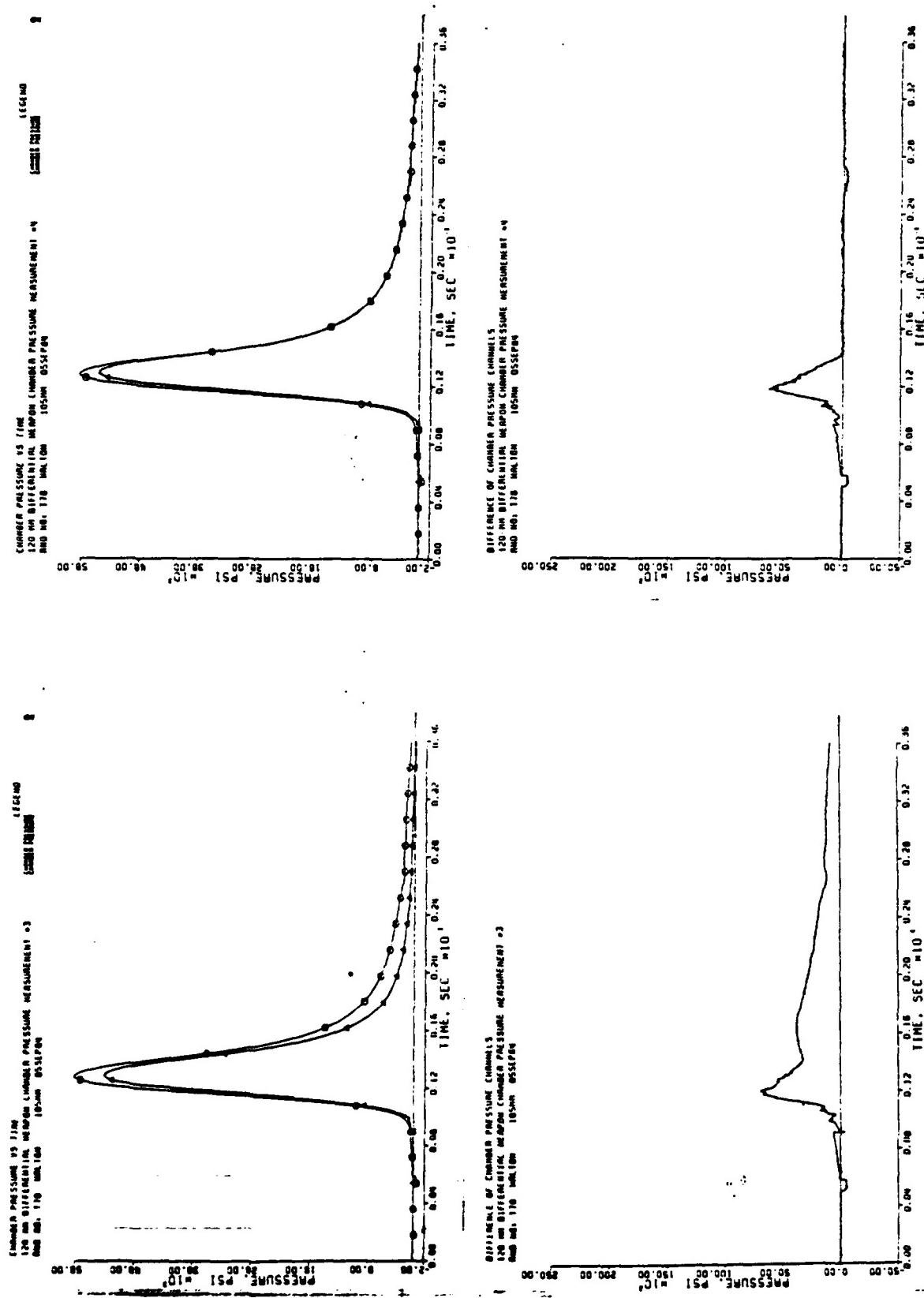


Figure 2.8-12b. Round No. T78.

## 2.8 (Cont'd)

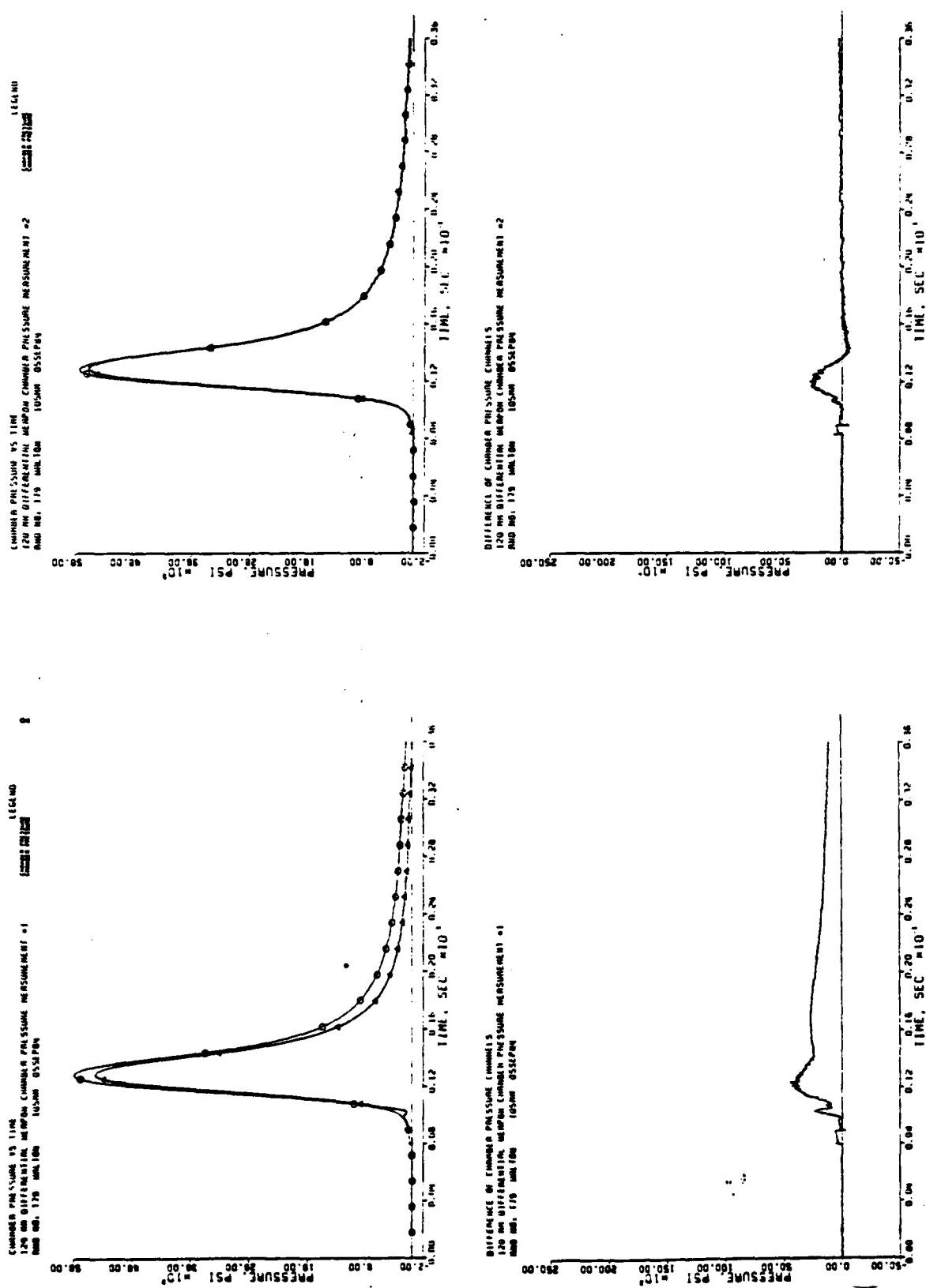


Figure 2.8-13a. Round No. 179.

2.8 (Cont'd)

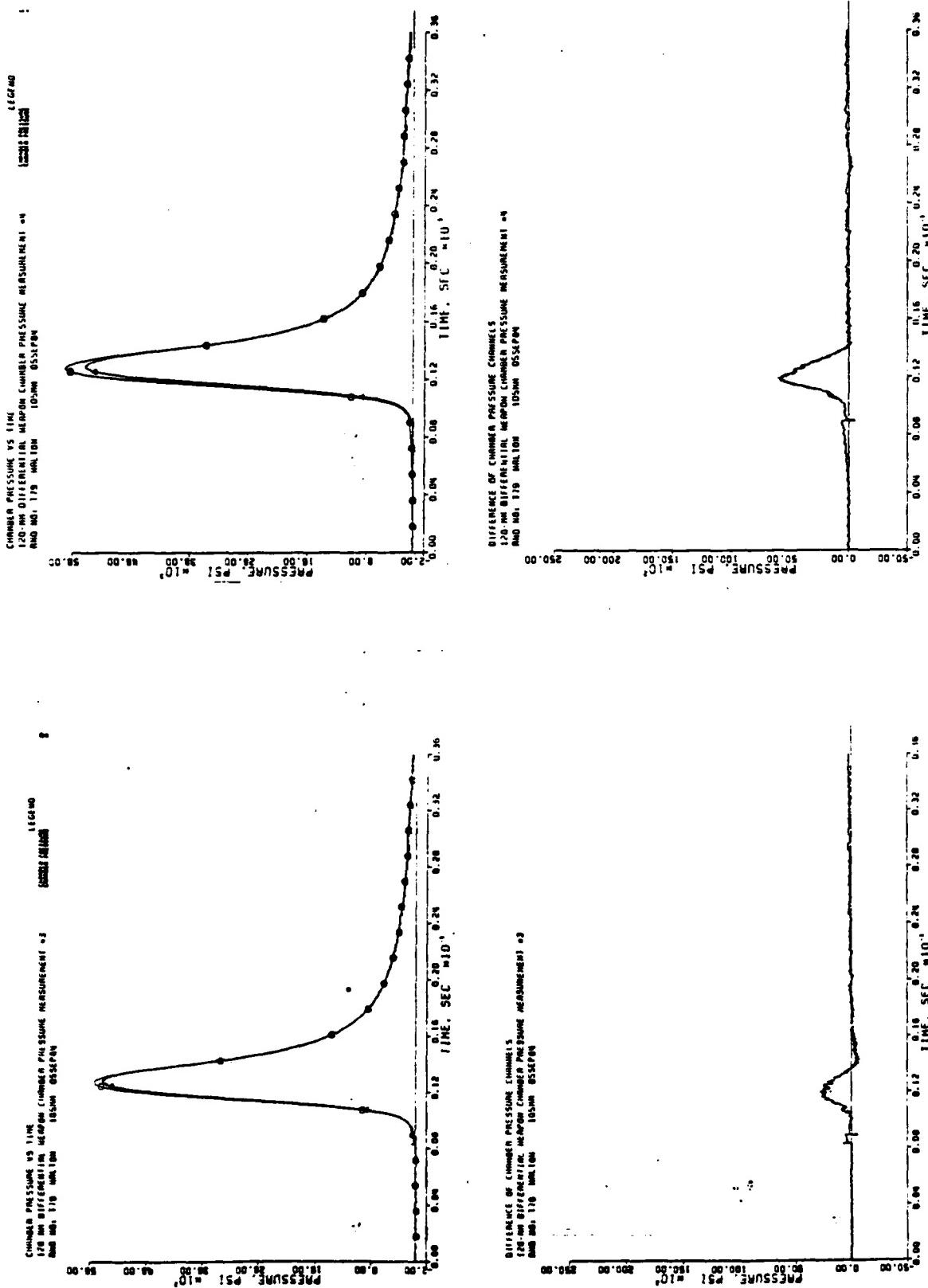


Figure 2.8-13b. Round No. T79.

## 2.9 PHASE IIc. ROUNDS 80 THROUGH 88, TUBE 25151

During the final phase of firing ES15 gages No. 25 and 8 were used in the right side of the tube. No position changes were made with this pair of gages. The 316 charge amplifier was used throughout the series of rounds. Three different pairs of Kistler gages were tested in the left side of the tube. Each gage pair had been used at some point earlier in the test, in the first tube.

The ES15 gages demonstrate variation in the return of the differential plots to zero baseline, similar to the performance during the previous phase. The differential peaks produced by the forward and rear gages are lower than the typical results observed throughout the test.

Each of the three sets of Kistler 6211 gages produce distinctly different differential peak pressures. Gages No. 151647 and 151652 have a consistent crossover apparent on the differential plots, and the resulting differential amplitudes are low. When the same set of gages was used in the first tube for rounds 1 through 13, there were slight problems with a negative offset on the differential records. When mounted in adapters during rounds 39 through 44, they exhibit a pronounced crossover and low differential peak pressures. Finally, the gage positions are changed during rounds 45 through 47, and the differential peak pressures become excessive. This pair of gages failed to produce good data in a variety of situations.

Gages No. 168653 and 168658 produce differential plots with satisfactory peak levels, minimal offset on the differential plots, and forward and rear peak pressures of acceptable levels. These gages were also used with adapters during rounds 48 through 60. Small variations in return to zero baseline are evident, but peak pressure levels and differential levels are acceptable. The performance of this pair of gages has been reliable through different mounting locations and a change of tubes.

Gages No. 151650 and 151653 demonstrate a consistent crossover effect on the differential records. The peak pressures produced by these gages are acceptable and the differential peak amplitudes are within expected levels. When these gages were tested during rounds 48 through 60, performance was not acceptable in tube No. 1 with No. 151650 in the forward position and No. 151653 in the rear position. A record of the problems experienced with this pair of gages would result in a significant savings in time and money on the test range.

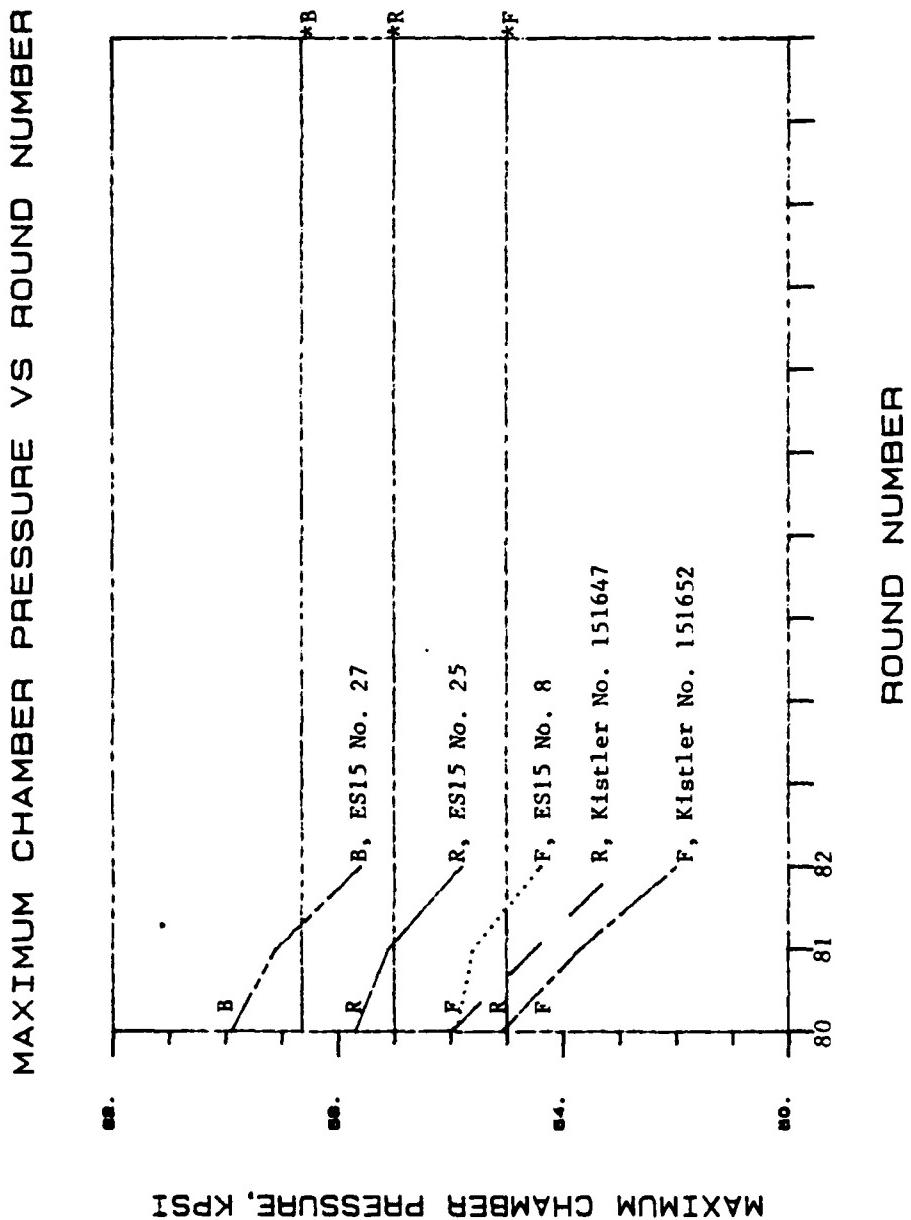
TABLE 2.9-1. CHAMBER PRESSURE DATA - PHASE IIIC

105-mm Tank Gun  
 Tube SN 25151  
 Cartridge: M392A2  
 Temperature: +70° F  
 Date Fired: 6 September 1994

Rd No.	Ch 1	Amp Position	Gage	Maximum Chamber Pressure, Kpsi				Maximum Initial +ΔP, psi				Base - Forward			
				ES15 No. 25				ES15 No. 27				Base - Forward			
				Gage Position	Ch 2	Amp Position	Ch 3	Gage Position	Ch 4	Amp Position	Ch 5	Gage Position	Ch 6	Channels 1 and 2	Channels 3 and 4
T80	57.7	316	Rear	55.9	316	Forward	56.0	316	Rear	55.1	316	Forward	59.9	316	Base
T81	57.1	316	Rear	55.6	316	Forward	54.5	316	Rear	53.7	316	Forward	59.1	316	Base
T82	55.8	316	Rear	54.4	316	Forward	53.0	316	Rear	52.0	316	Forward	57.6	316	Base
				ES15 No. 25	ES15 No. 8	ES15 No. 53	Kistler No. 151647	Kistler No. 151652	Kistler No. 168653	Kistler No. 168658	Kistler No. 168658				
T83	56.4	316	Rear	54.9	316	Forward	57.0	316	Rear	54.7	316	Forward	58.3	316	Base
T84	57.0	316	Rear	55.7	316	Forward	57.6	316	Rear	54.4	316	Forward	59.1	316	Base
T85	57.1	316	Rear	55.6	316	Forward	57.8	316	Rear	54.8	316	Forward	58.7	316	Base
				ES15 No. 25	ES15 No. 8	ES15 No. 50	Kistler No. 151647	Kistler No. 151653	Kistler No. 151650	Kistler No. 151653	Kistler No. 151653				
T86	55.9	316	Rear	54.4	316	Forward	55.6	316	Rear	54.1	316	Forward	57.9	316	Base
T87	57.3	316	Rear	55.8	316	Forward	57.4	316	Rear	55.4	316	Forward	59.3	316	Base
T88	56.8	316	Rear	55.3	316	Forward	57.4	316	Rear	56.9	316	Forward	58.8	316	Base

Ch = Channel.

2.9 (Cont'd)

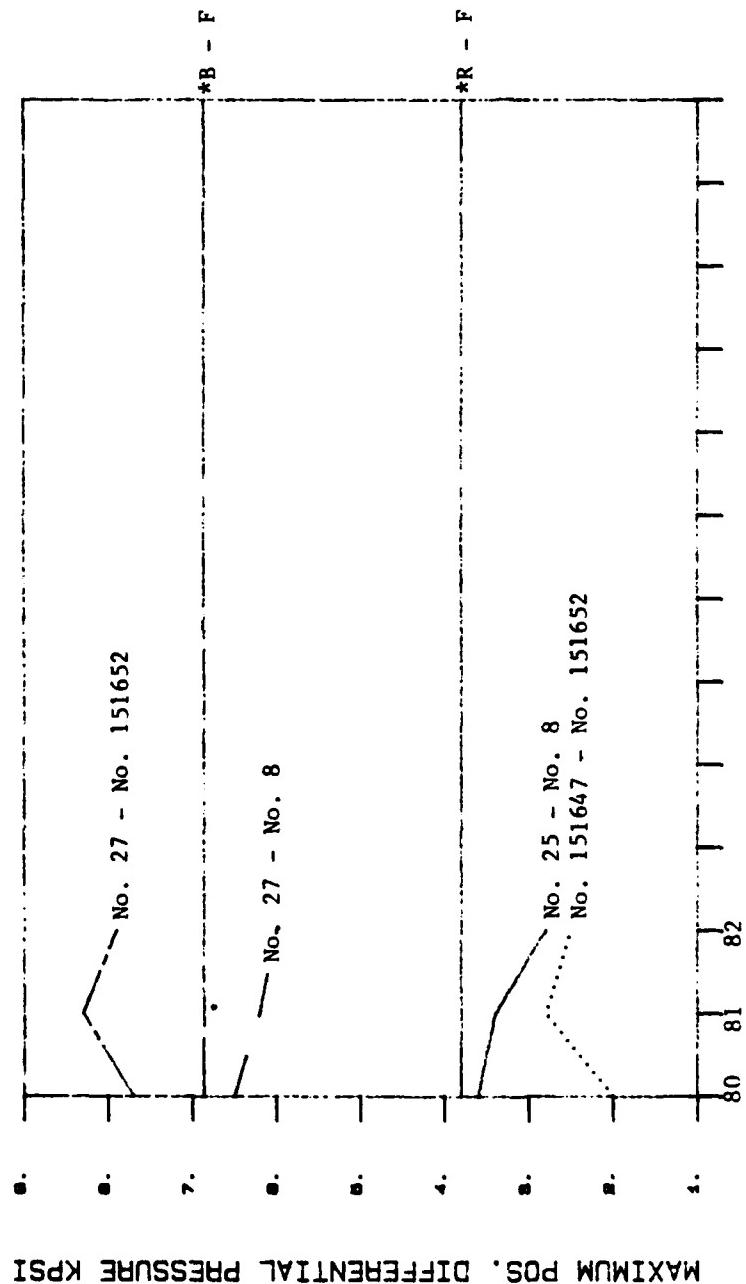


F = Forward gage position.  
R = Rear gage position.  
B = Base gage position.  
\* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.9-1 (1). Maximum chamber pressure.

2.9 (Cont'd)

MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



ROUND NUMBER

R - F = Rear minus forward gage.

B - F = Base minus forward gage.

\* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.9-1(2). Maximum positive differential pressure.

2.9 (Cont'd)

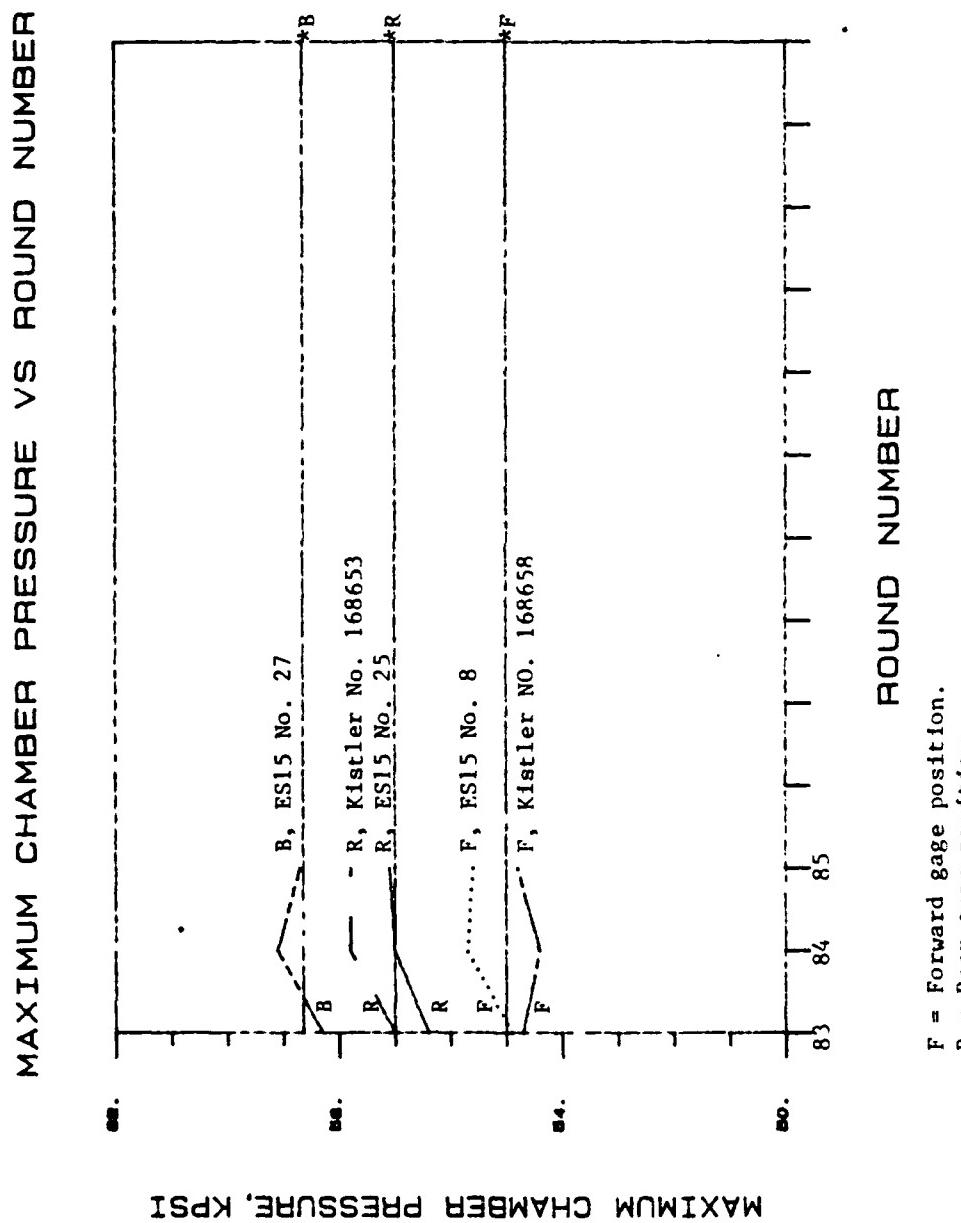


Figure 2.9-1(3). Maximum chamber pressure.

.9 (Cont'd)

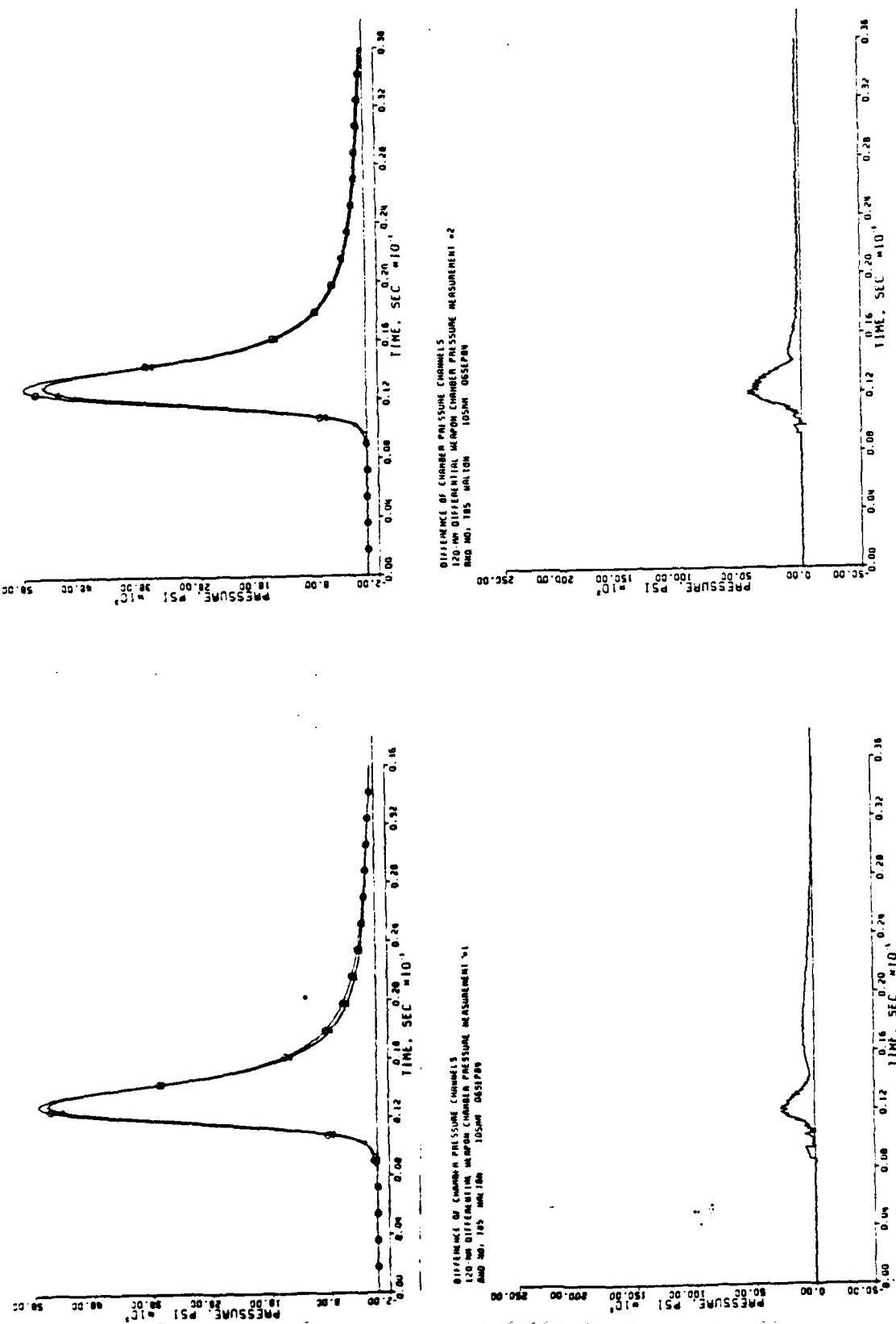


Figure 2.9-6a. Round No. T85.

### 2.9 (Cont'd)

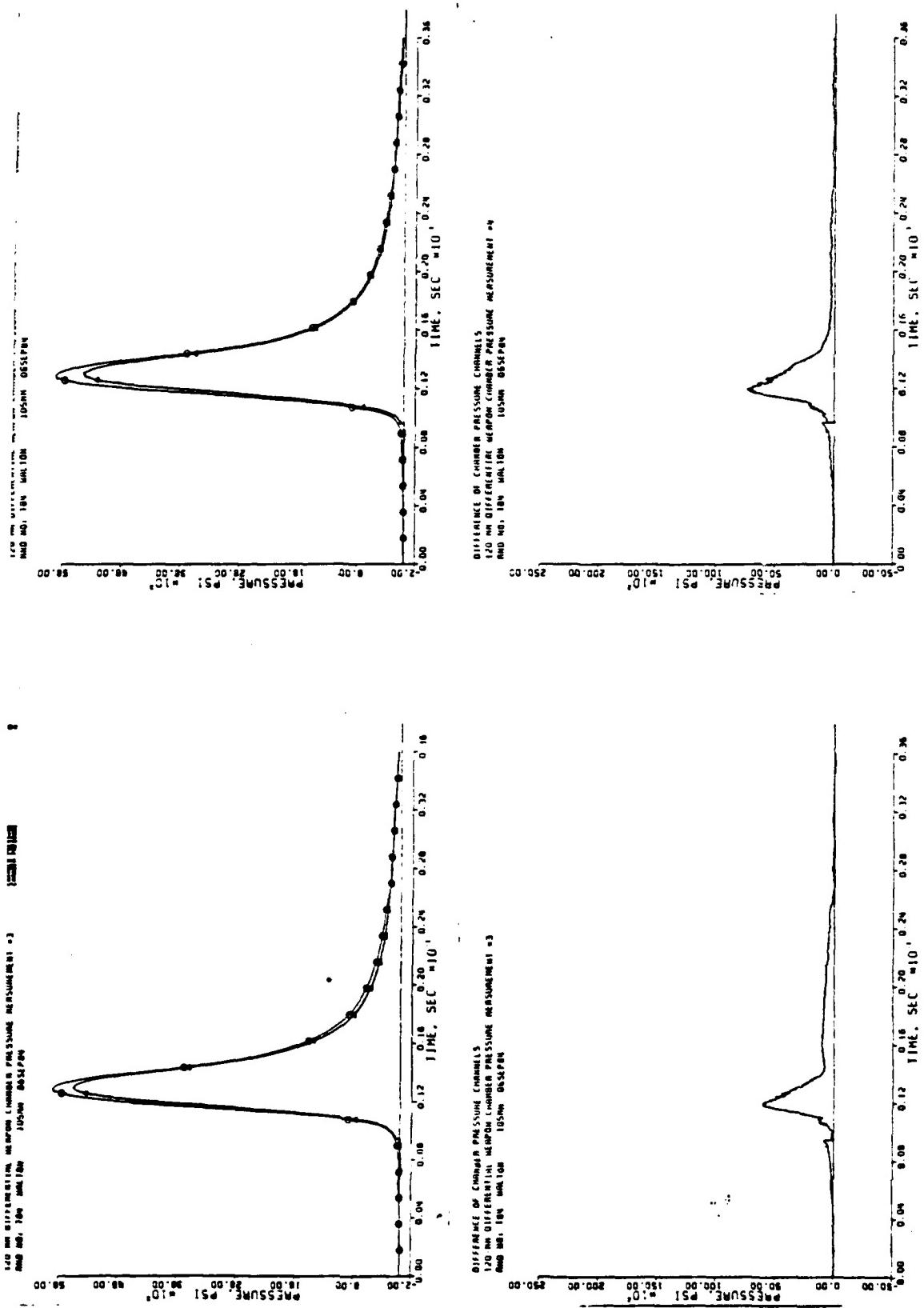


Figure 2.9-5b. — Round No. T84.

2.9 (Cont'd)

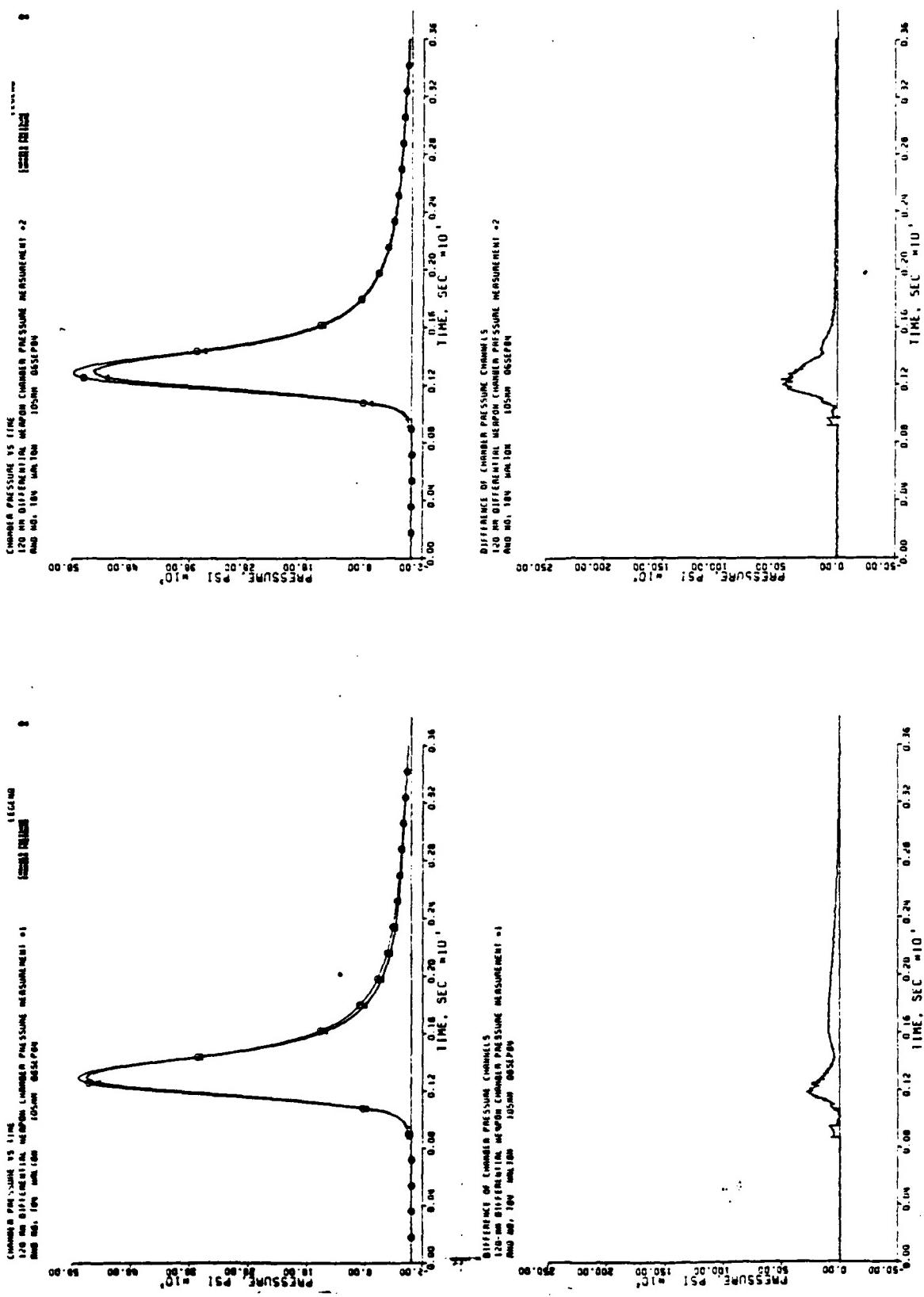


Figure 2.9-5a. Round No. T84.

## 2.9 (Cont'd)

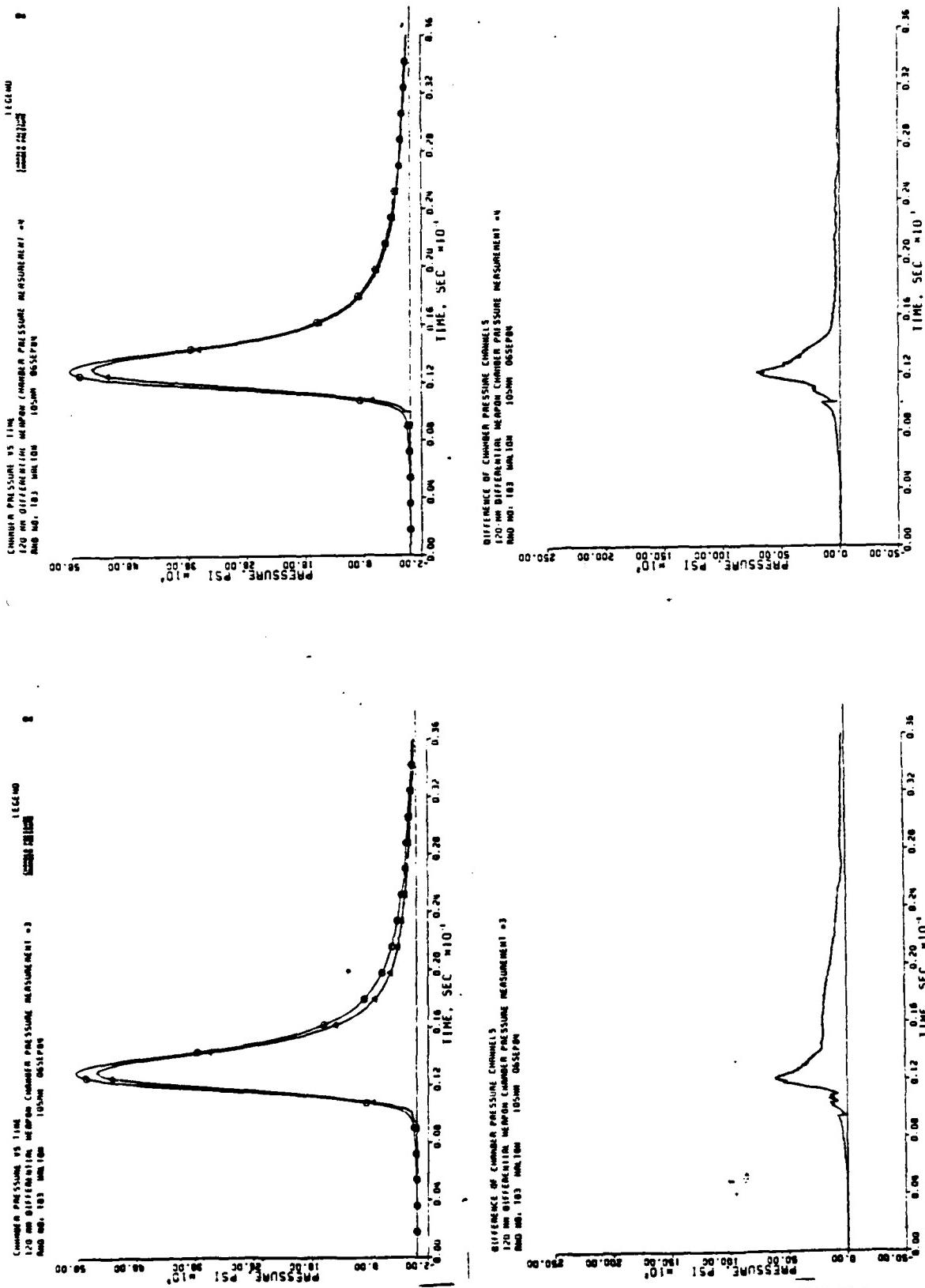


Figure 2.9-4b. Round No. T83.

2.9 (Cont'd)

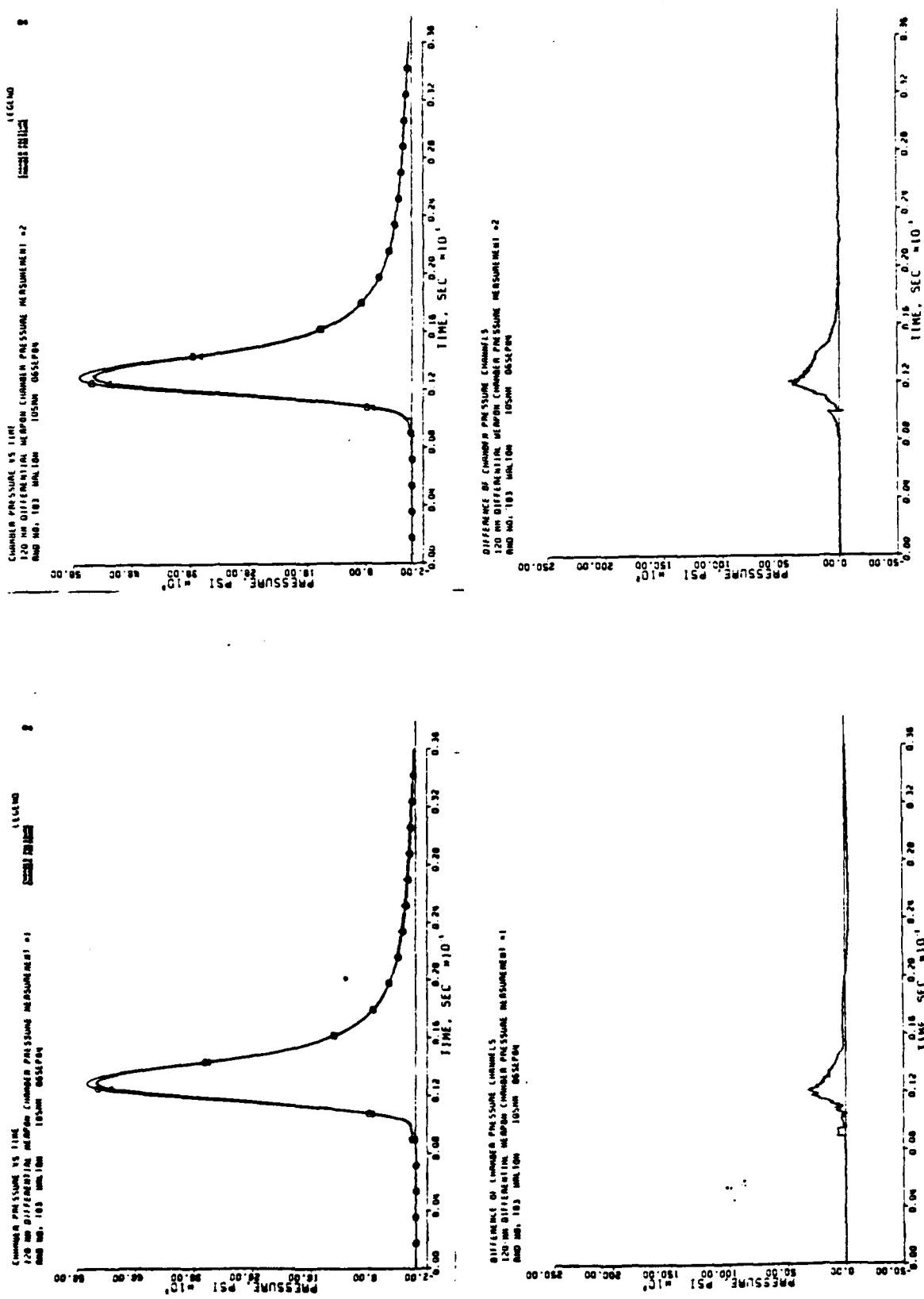


Figure 2.9-4a. Round No. 183.

2.9 (Cont'd)

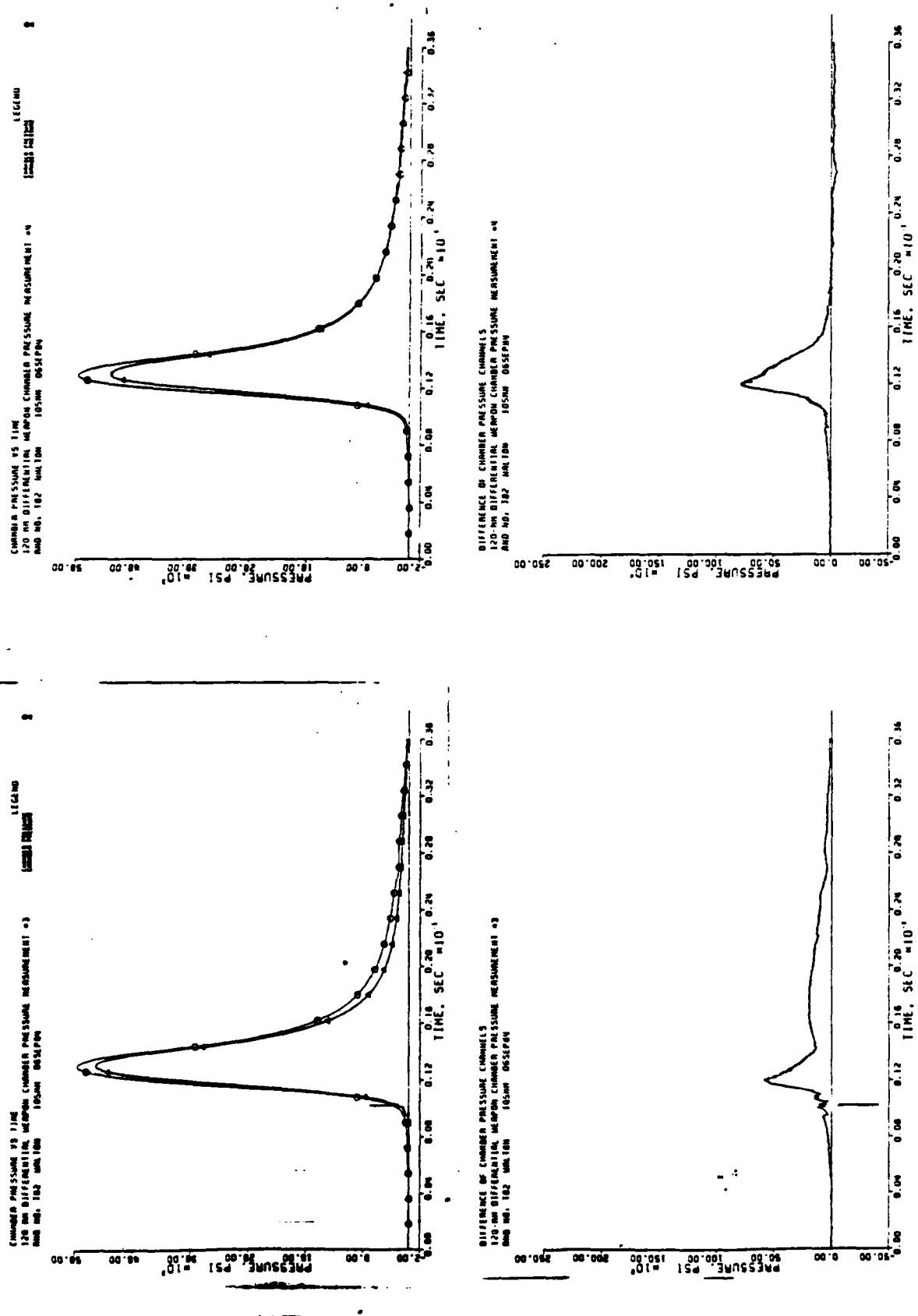
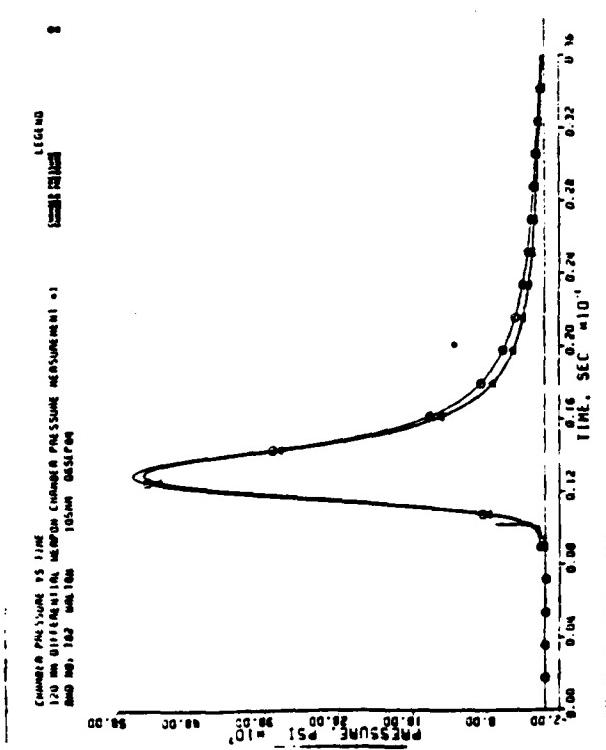
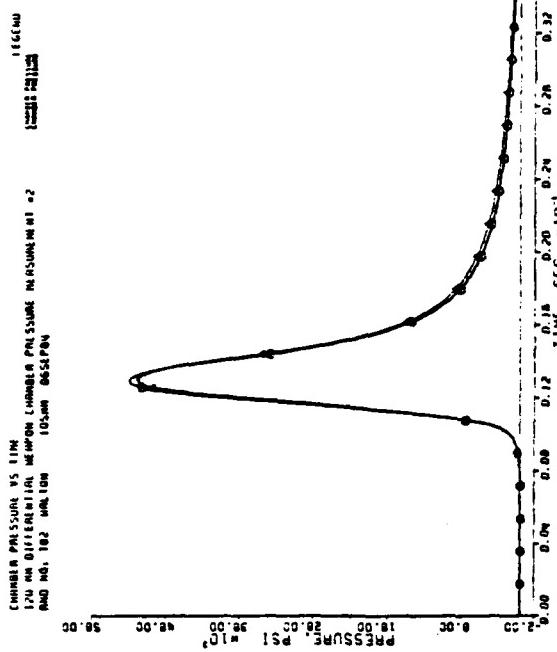


Figure 2.9-3b. Round No. T82.

2.9 (Cont'd)



BESTIMENT OF CHAMBER PRESSURE CHANNELS  
120 MM DIFFERENTIAL DIAPHRAGM CHAMBER PRESSURE MEASUREMENT NO. 1  
RND NO. 182 105MM DISPLA 105MM DISPLA



BESTIMENT OF CHAMBER PRESSURE CHANNELS  
120 MM DIFFERENTIAL DIAPHRAGM CHAMBER PRESSURE MEASUREMENT NO. 2  
RND NO. 182 105MM DISPLA 105MM DISPLA

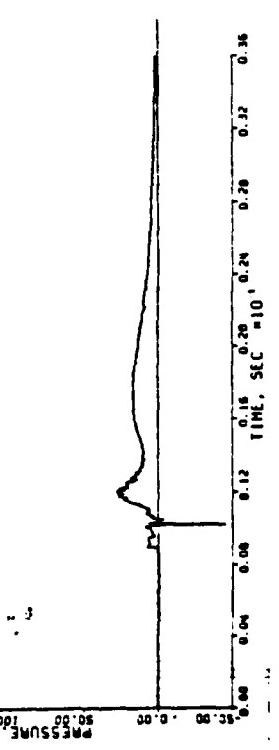


Figure 2.9-3a. Round No. T82.

2.9 (Cont'd)

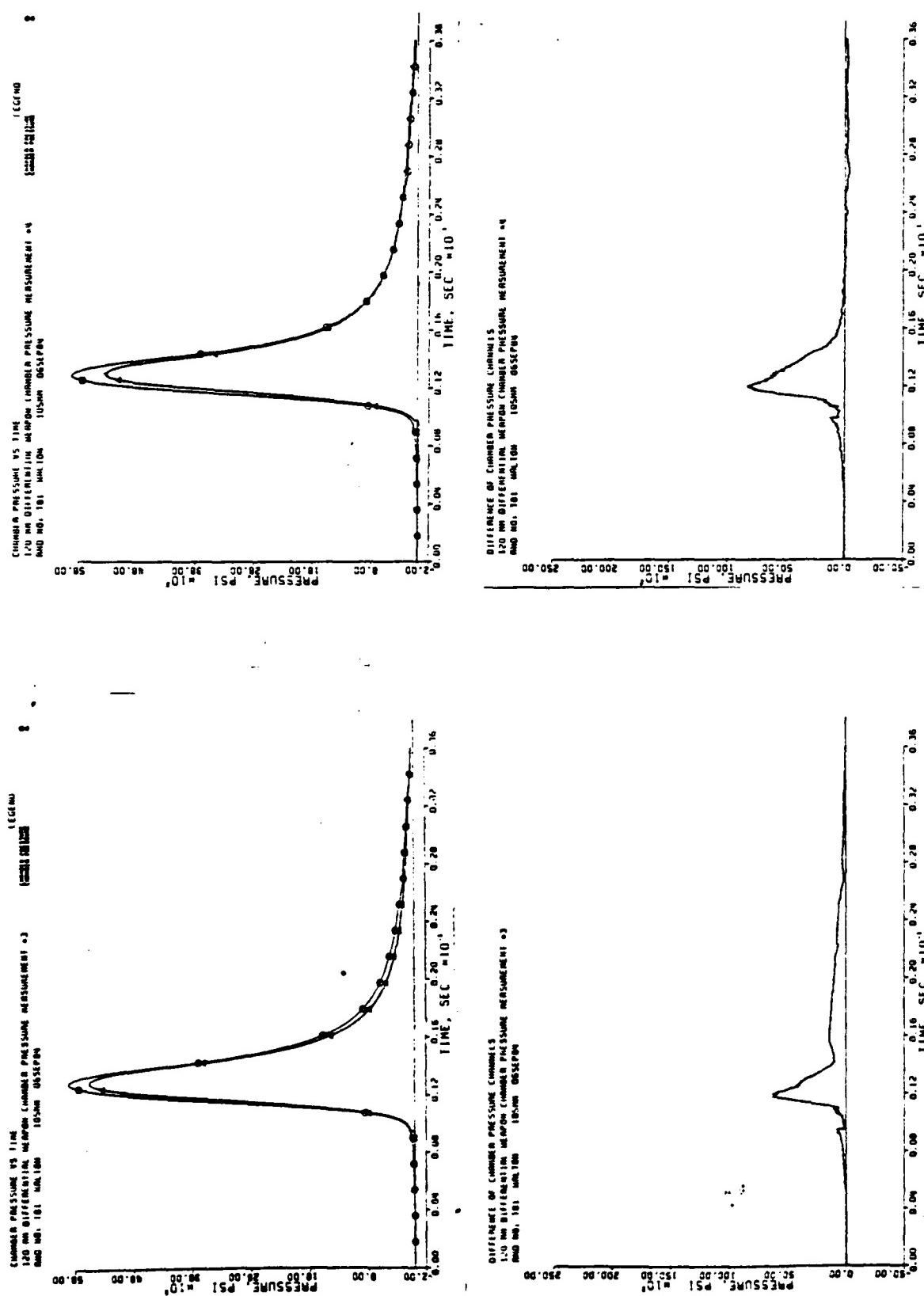


Figure 2.9-2b. Round No. T81.

### 2.9 (Cont'd)

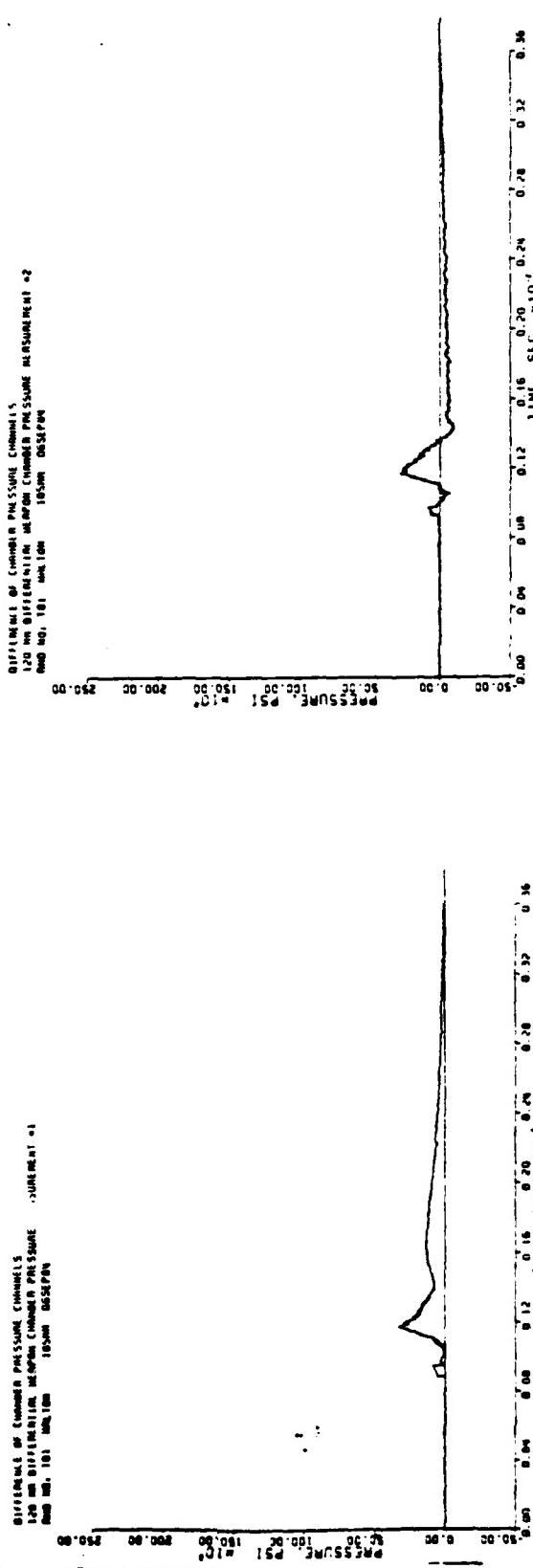
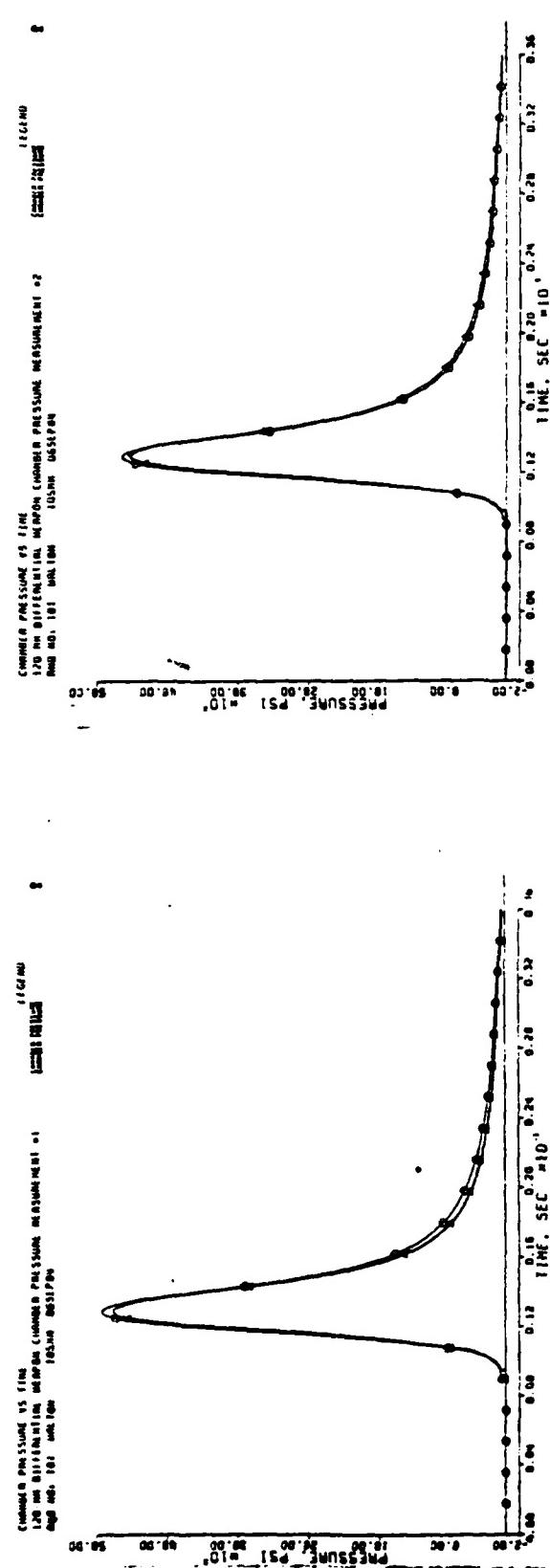
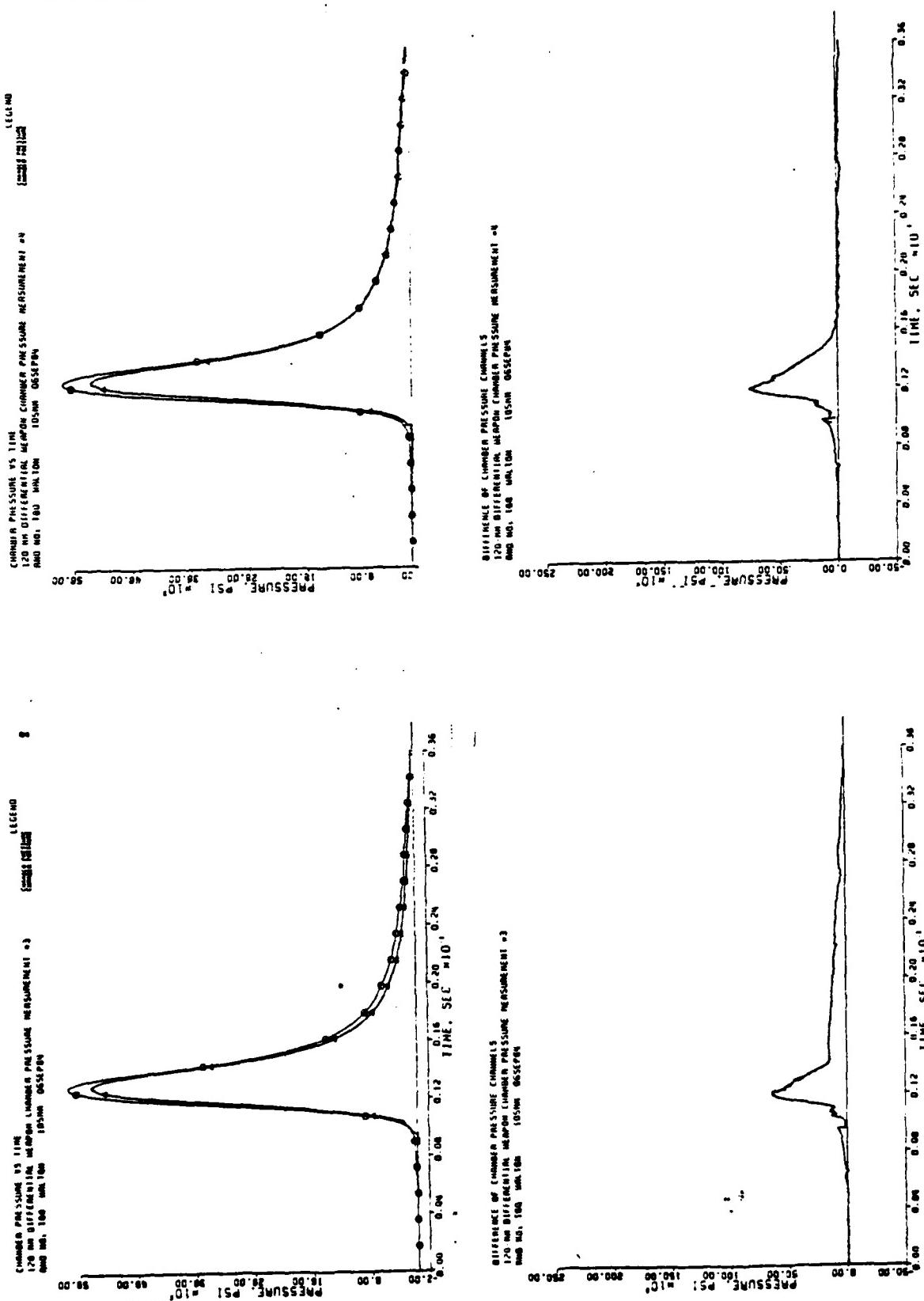


Figure 2.9-2a. Round No. T81.

2.9 (Cont'd)



2.9 (Cont'd)

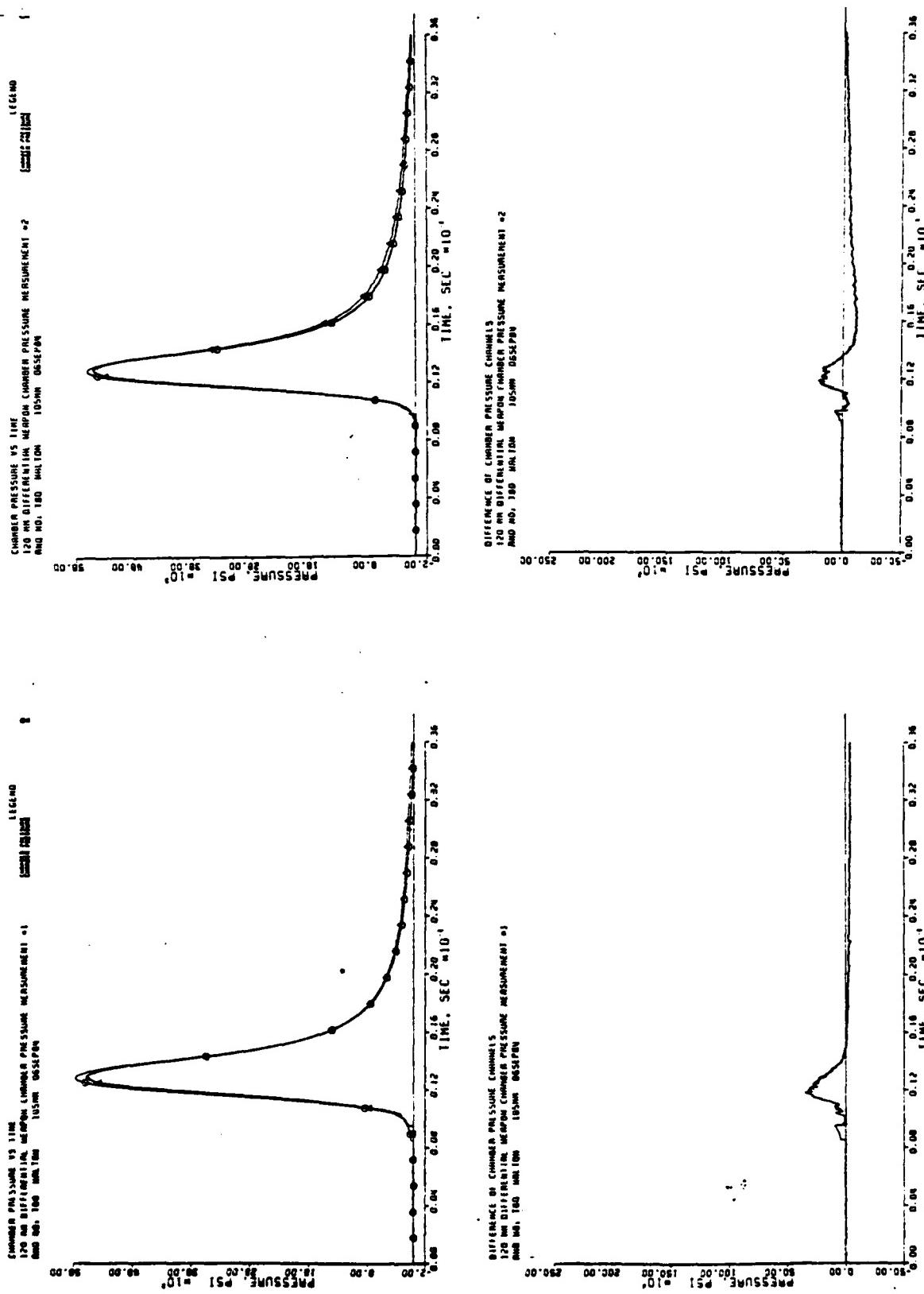
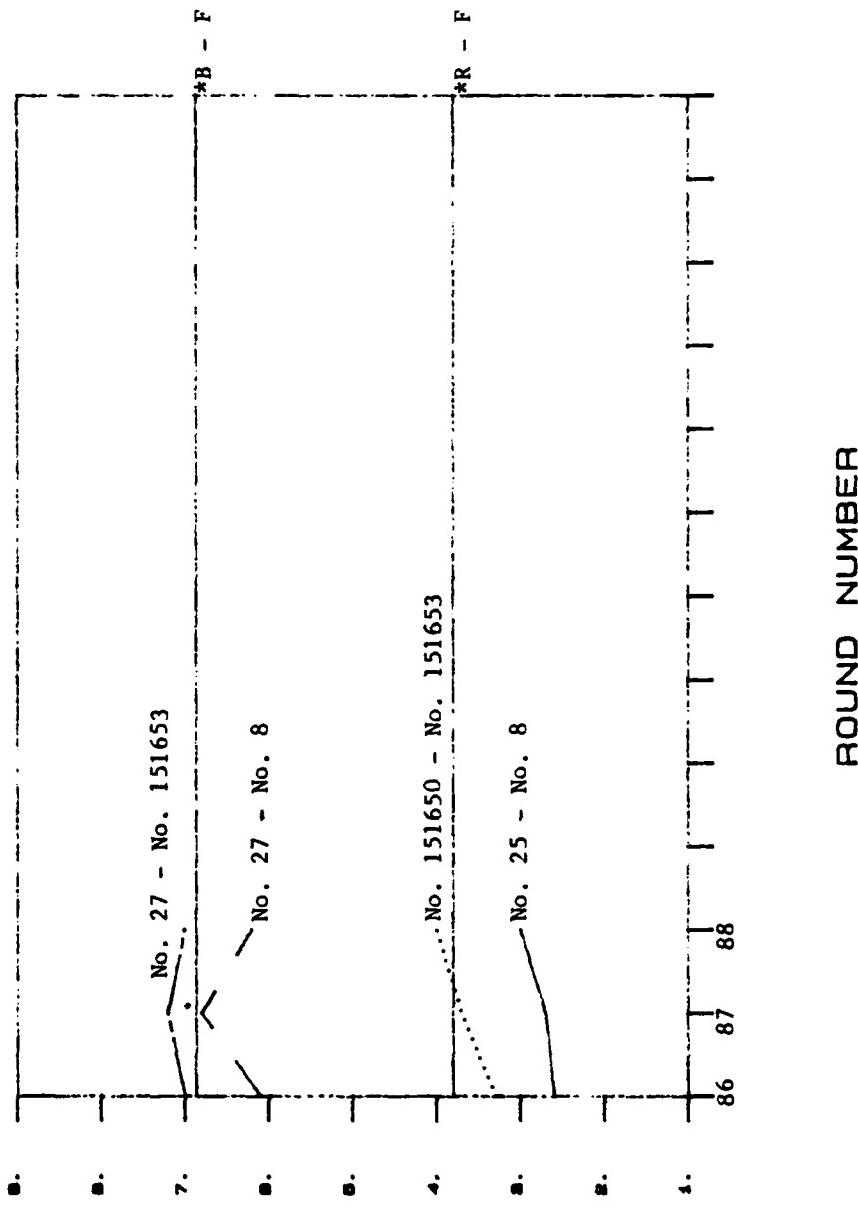


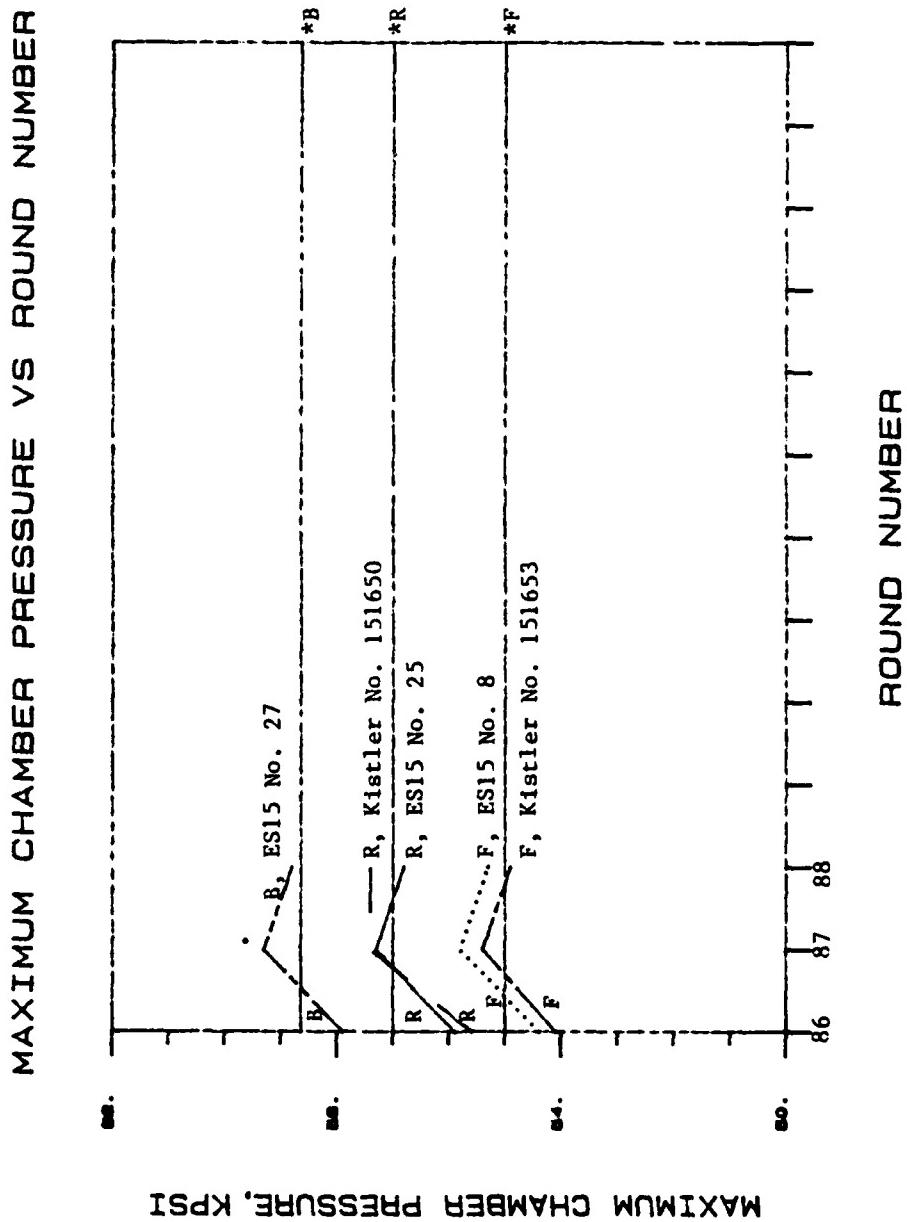
Figure 2.9-1a. Round No. T80.

## MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.  
 B - F = Base minus forward gage.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.9-1(6). Maximum positive differential pressure.

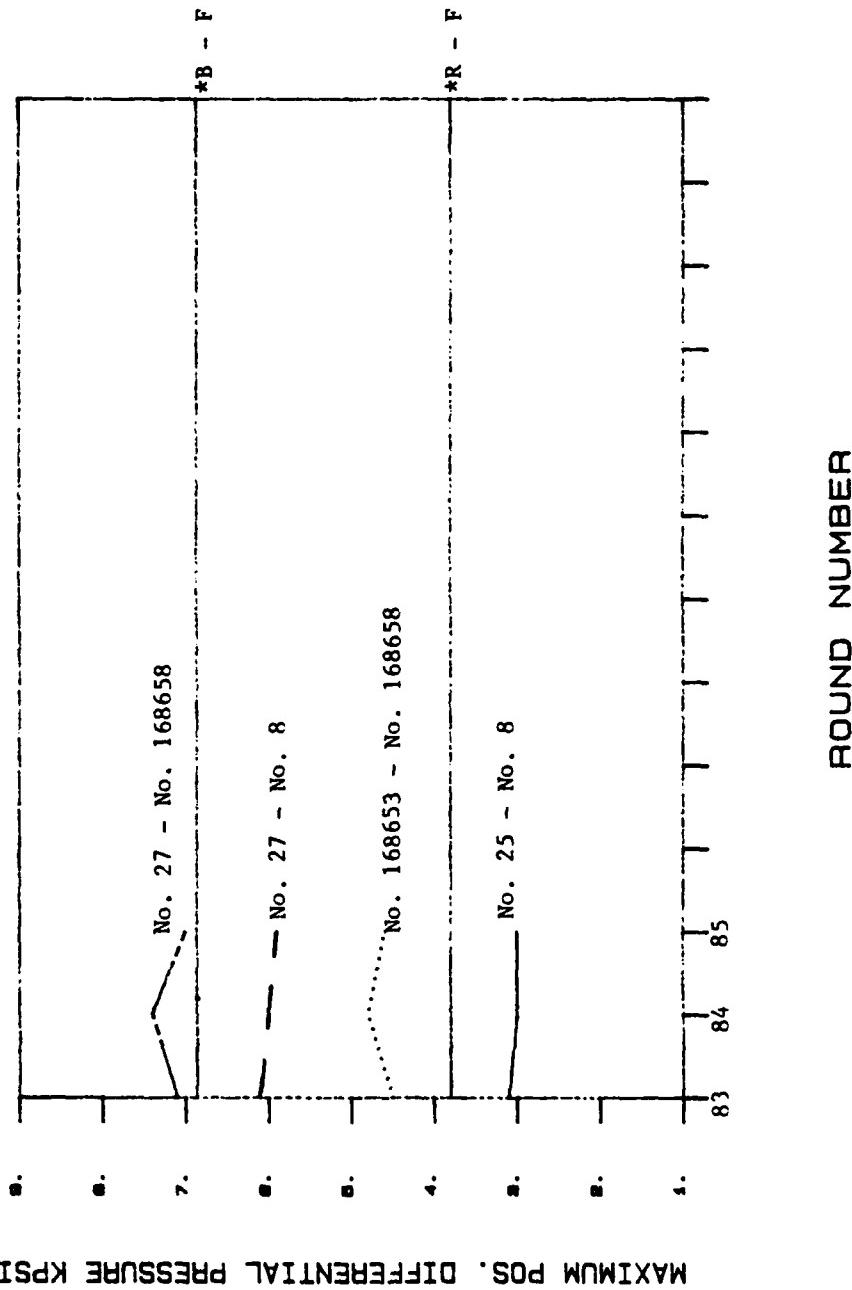


F = Forward gage position.  
 R = Rear gage position.  
 B = Base gage position.  
 \* = Average pressure throughout test, all gages, all rounds fired.

Figure 2.9-1(5). Maximum chamber pressure.

2.9 (Cont'd)

MAXIMUM POS. DIFFERENTIAL PRESSURE VS ROUND NUMBER



R - F = Rear minus forward gage.  
B - F = Base minus forward gage.  
\* = Average pressure throughout test, all gages, all rounds fired.

2.9-1(4). Maximum positive differential pressure.

2.9 (Cont'd)

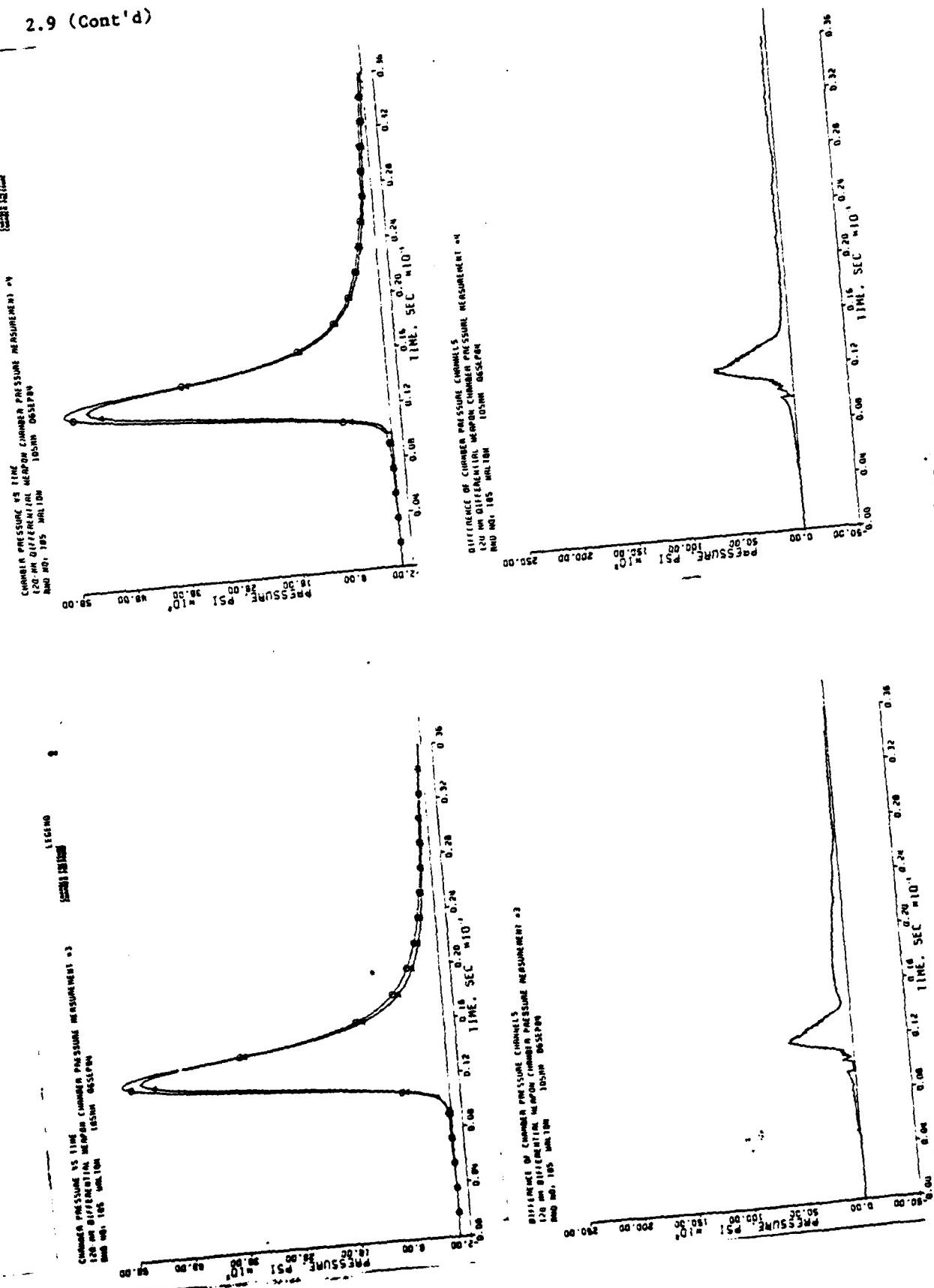


Figure 2.9-6b. Round No. T85.

2.9 (Cont'd)

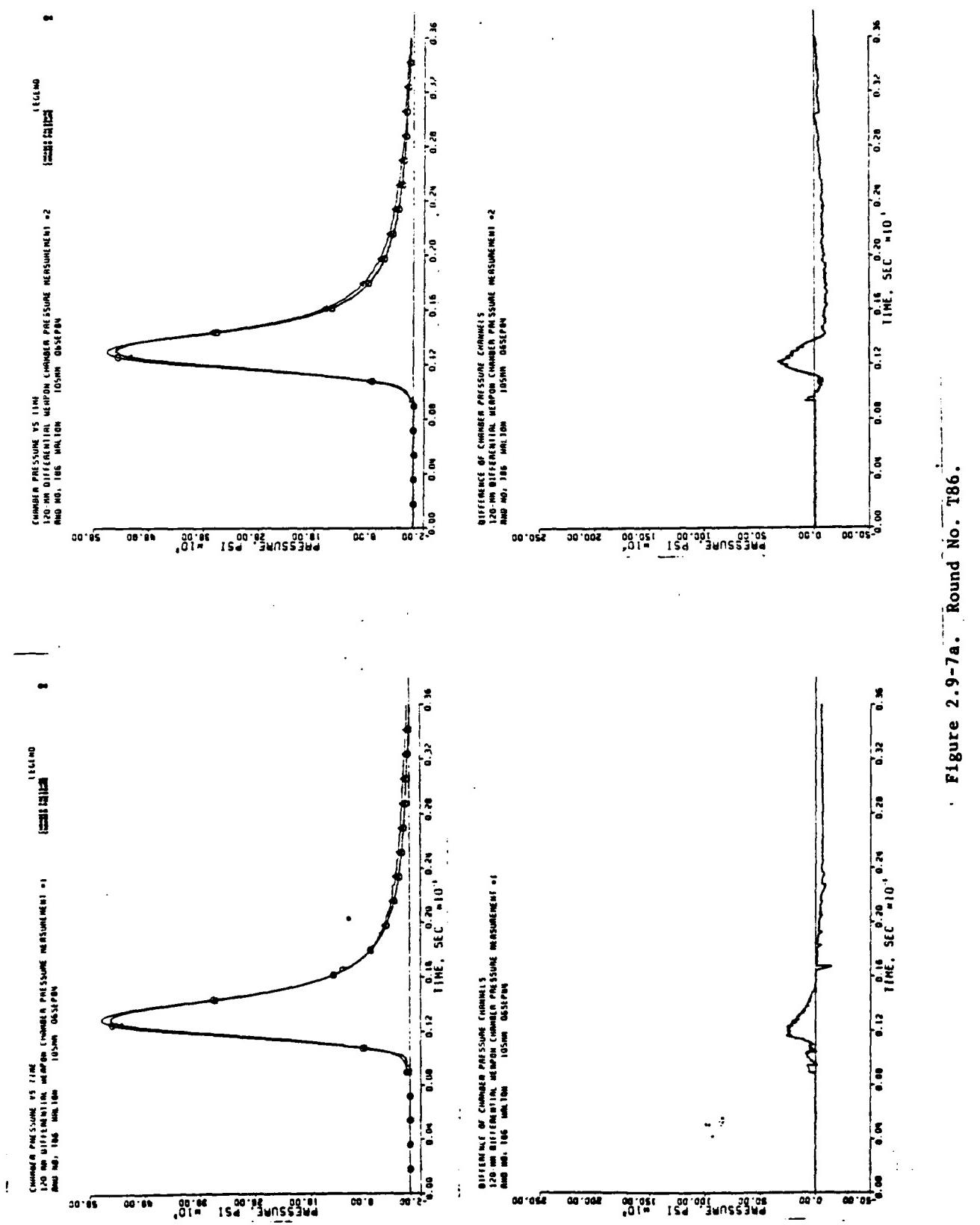


Figure 2.9-7a. Round No. T86.

2.9 (Cont'd)

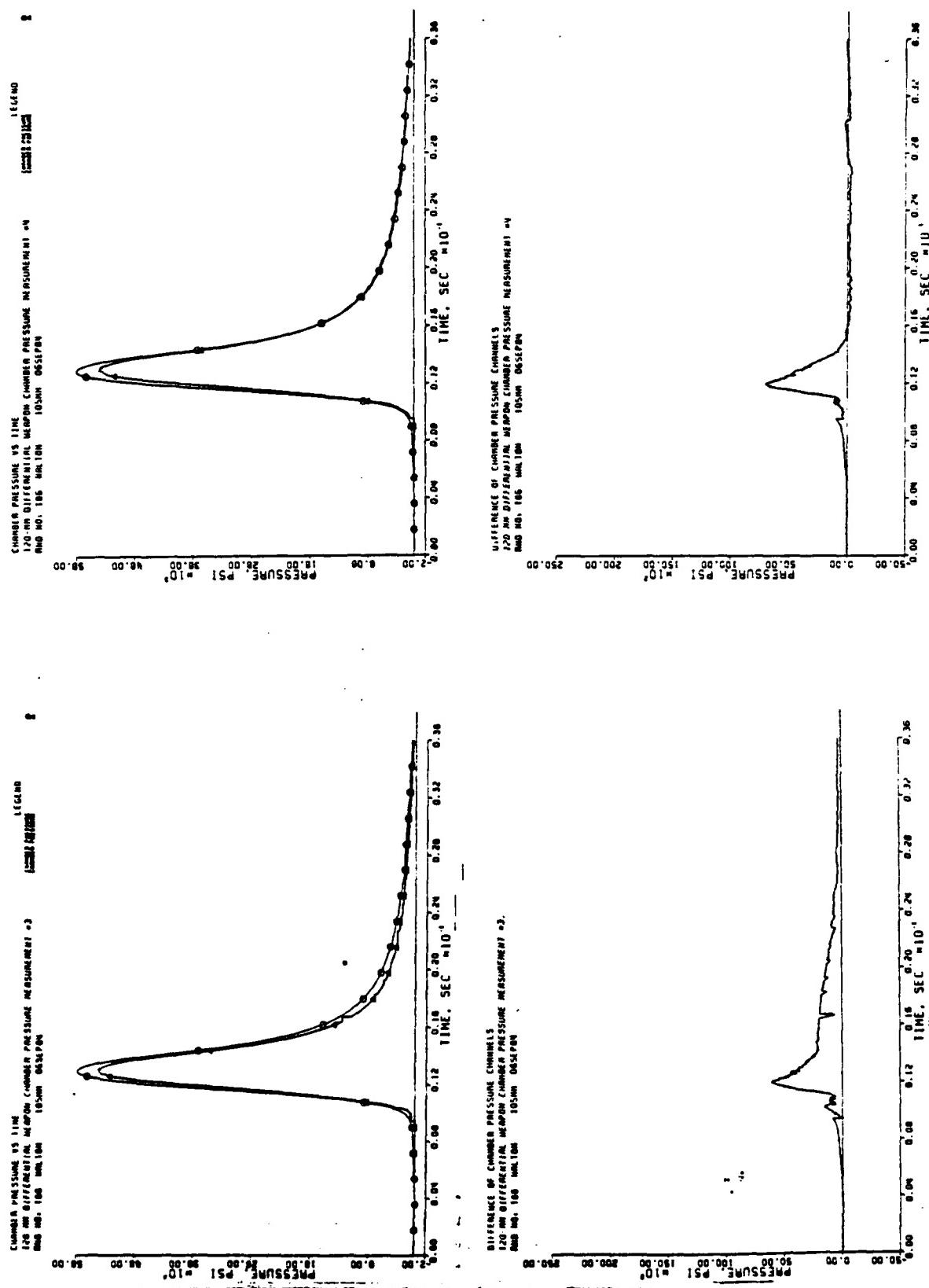


Figure 2.9-7b. Round No. T86.

2.9 (Cont'd)

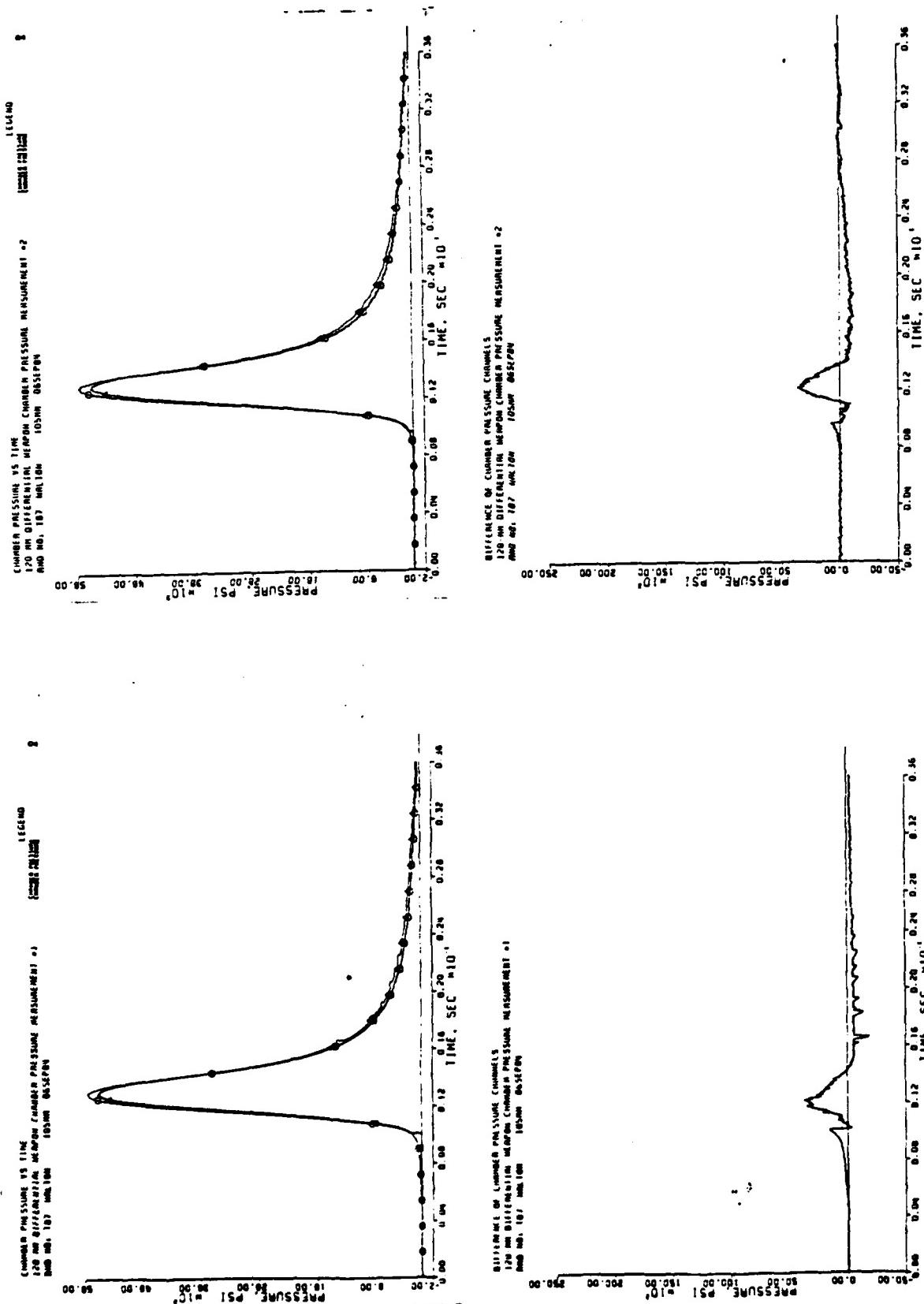


Figure 2.9-8a. Round No. T87.

2.9 (Cont'd)

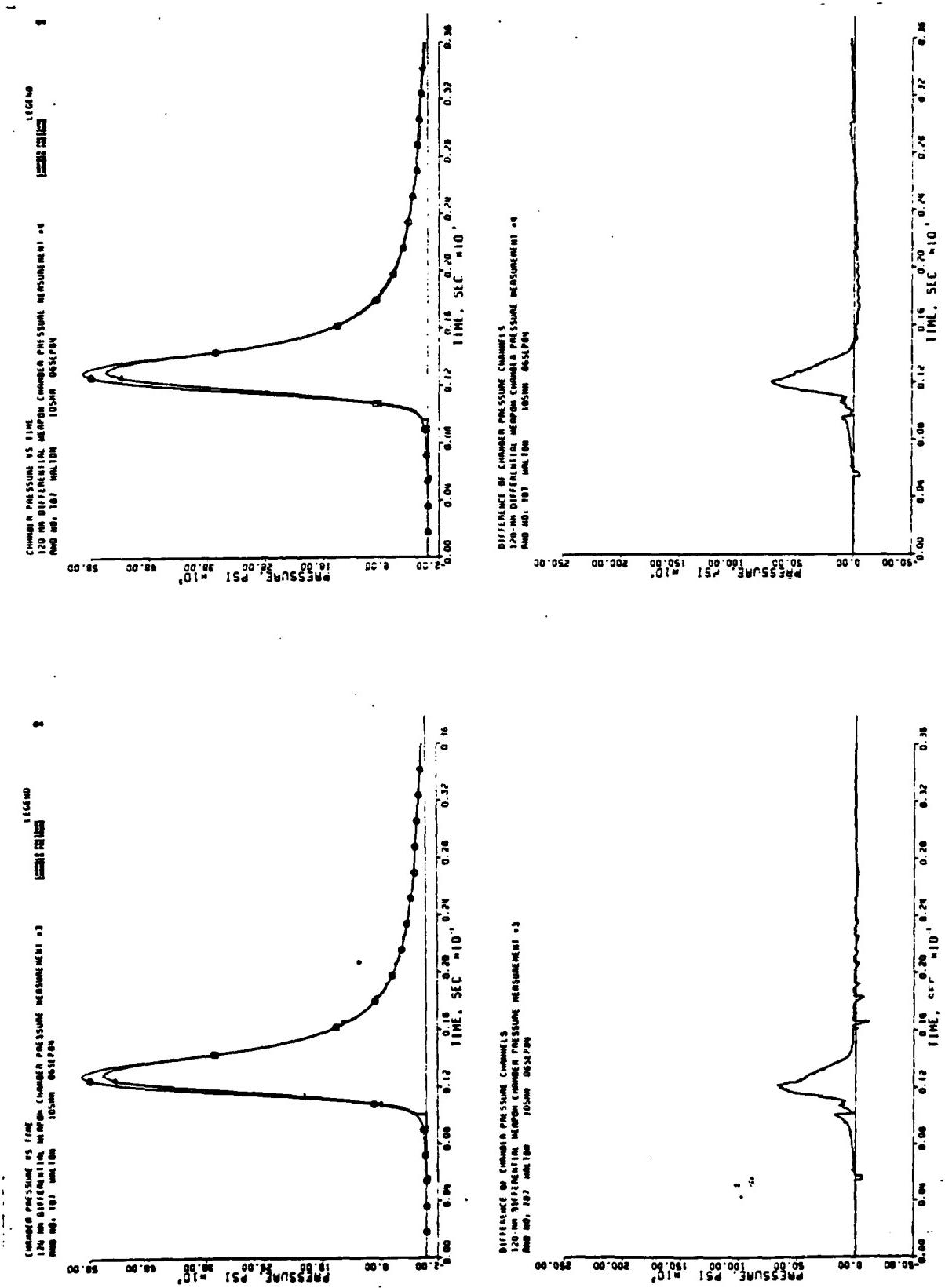


Figure 2.9-8b. — Round No. T87.

2.9 (Cont'd)

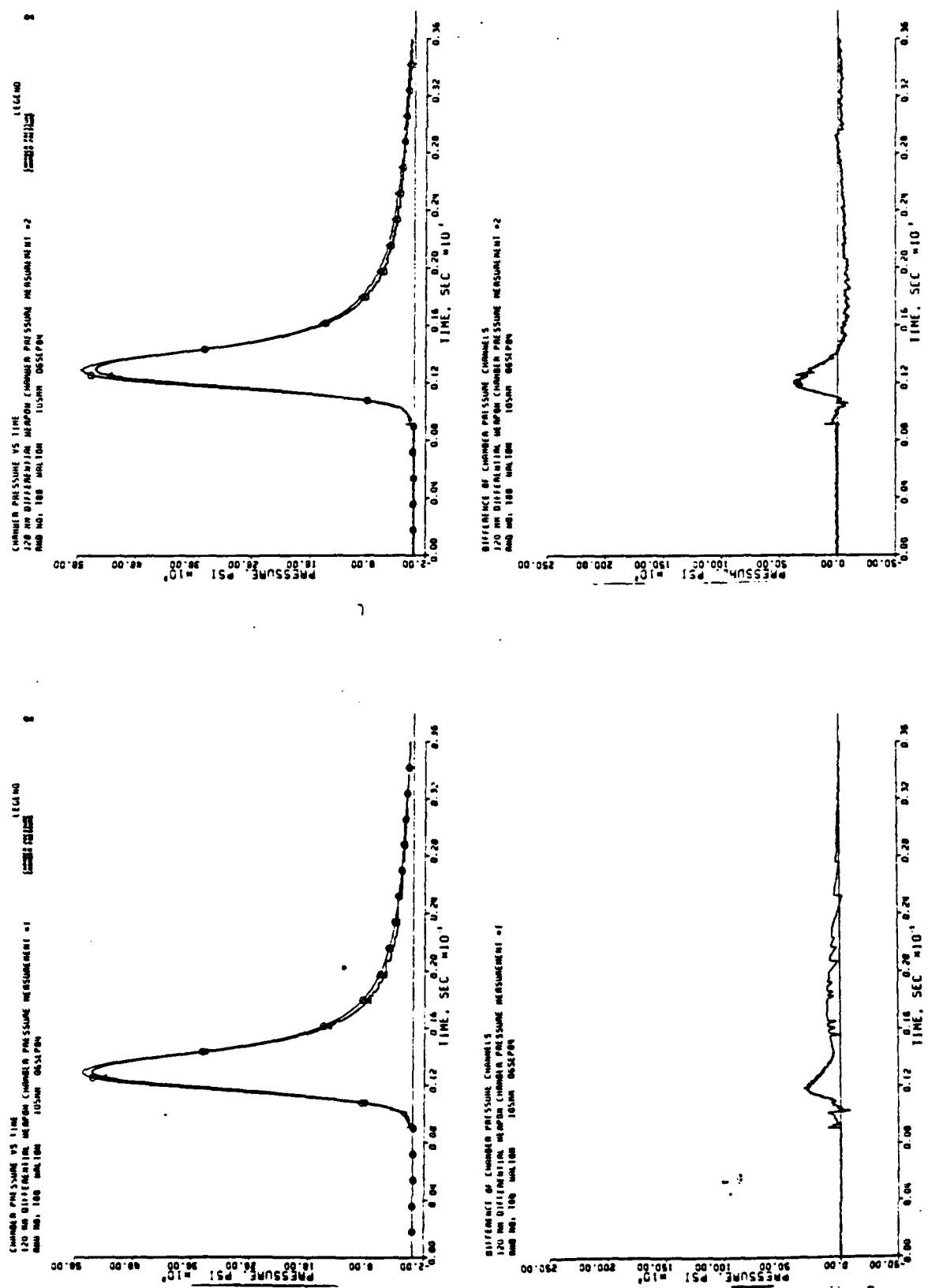


Figure 2.9-9a. Round No. T88.

### 2.9 (Cont'd)

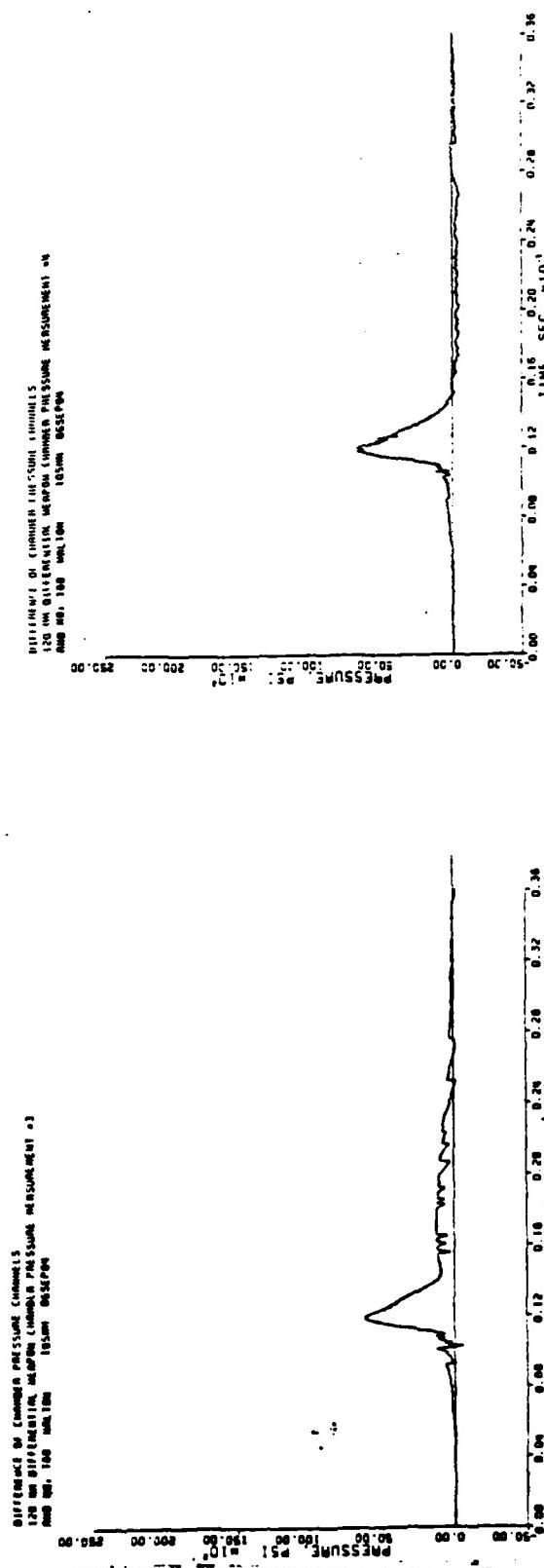
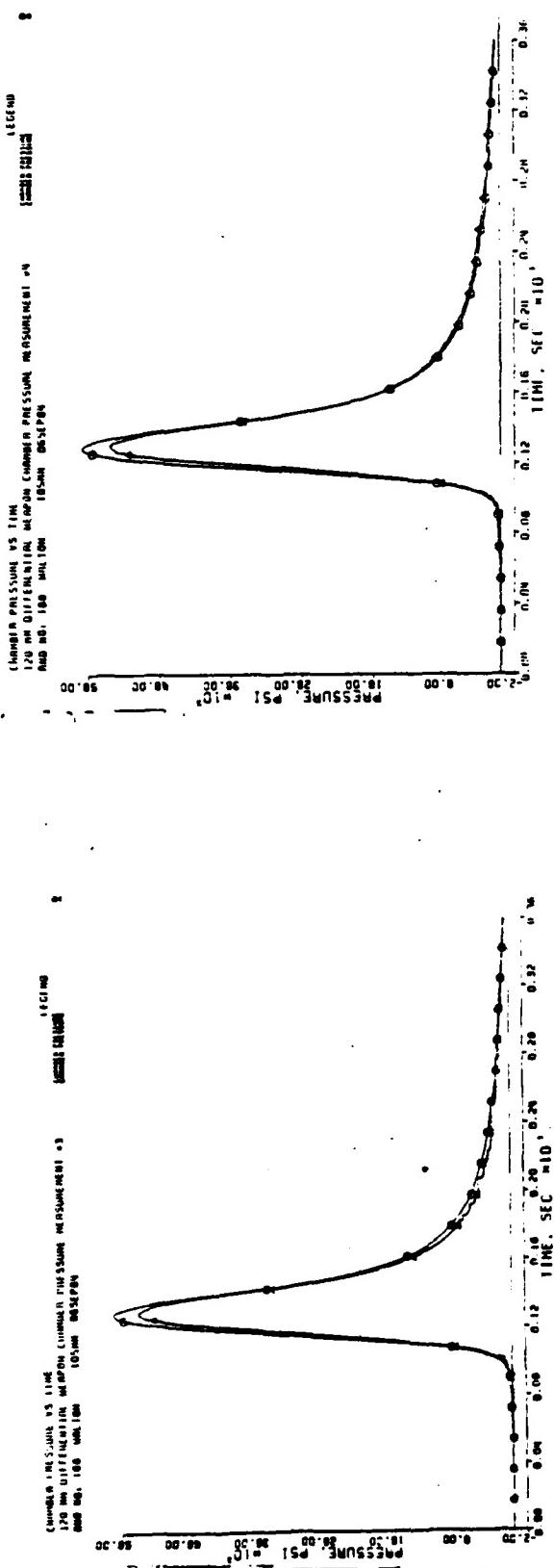


Figure 2.9-9b. Round No. T88.

## 2.10 TRANSDUCER NONLINEARITY CORRECTION

Reference 1 discusses the nonlinearity of standard chamber pressure transducers. In general, the calibration points are fit to a line by a first order least squares method or by a best straight line through zero method. However, worse case errors of several percent in the fit are not unusual. Since the differential pressures are generated from data which has been scaled by calibration results fit to a line, it was proposed that the nonreturn to zero of the differential record might be attributed to the nonlinearity of the transducers.

To investigate this possibility, a program was written to linearize the raw data to take into account the nonlinearity of the transducer. The linearization program reads the raw data, scales it with a fourth order polynomial derived from the transducer calibration data, and writes the scaled data into a new record. The new data record can then be processed in the same manner as the old record.

The linearization was applied to a set of records which showed a nonreturn to zero in the differential. Table 2.10-1 contains the calibration data and fit error for the two transducers used in the test. Although the first order fit shows some nonlinearity in the two gages, it is not excessive when the calibration and gage accuracy are considered. The fourth order fit coefficients were used to linearize the raw data and a new differential record was created. Figure 2.10-1 is a plot of the raw data and linearized data differential records. The linearized record does not differ significantly from the original record.

TABLE 2.10-1. TRANSDUCER FIT ERRORS FOR YPG  
TOURMALINE EXTERNAL GAGES

Pressure (psi)	Gage Output (psi)	1st Order Fit Error (psi)	2nd Order Fit Error (psi)	3rd Order Fit Error (psi)	4th Order Fit Error (psi)
SN EL805					
80,000	77,625	15	95	19	4
70,000	68,057	-135	-119	-53	-16
60,000	58,222	- 11	- 42	39	28
50,000	48,437	. 60	2	12	-23
40,000	38,634	151	82	-17	7
0	0	- 79	- 16	1	0
RMS Error (psi)		93	73	29	17
Largest error (%)		0.37	0.20	0.08	0.05

## 2.10 (Cont'd)

TABLE 2.10-1 (CONT'D)

Pressure (psi)	Gage Output (psi)	1st Order Fit Error (psi)	2nd Order Fit Error (psi)	3rd Order Fit Error (psi)	4th Order Fit Error (psi)
SN EL807					
80,000	80,343	193	93	17	2
70,000	70,568	- 90	-111	-45	- 9
60,000	60,513	- 94	- 57	25	15
50,000	50,421	- 61	11	22	-12
40,000	40,307	- 7	79	-20	4
0	0	61	- 16	1	0
RMS Error (psi)		101	72	25	9
Largest error (%)	0.24	0.20	0.06	0.03	

An examination of the differential record shows that the nonreturn to zero begins at approximately 35,000 psi on a pressure channel. However, the test gages were not calibrated below 40,000 psi. The gages were returned to the calibration shop and new calibrations were performed with additional points included at 5,000, 10,000, 15,000, 20,000, and 30,000 psi. The linearization procedure was then repeated with the same results.

2.10 (Cont'd)

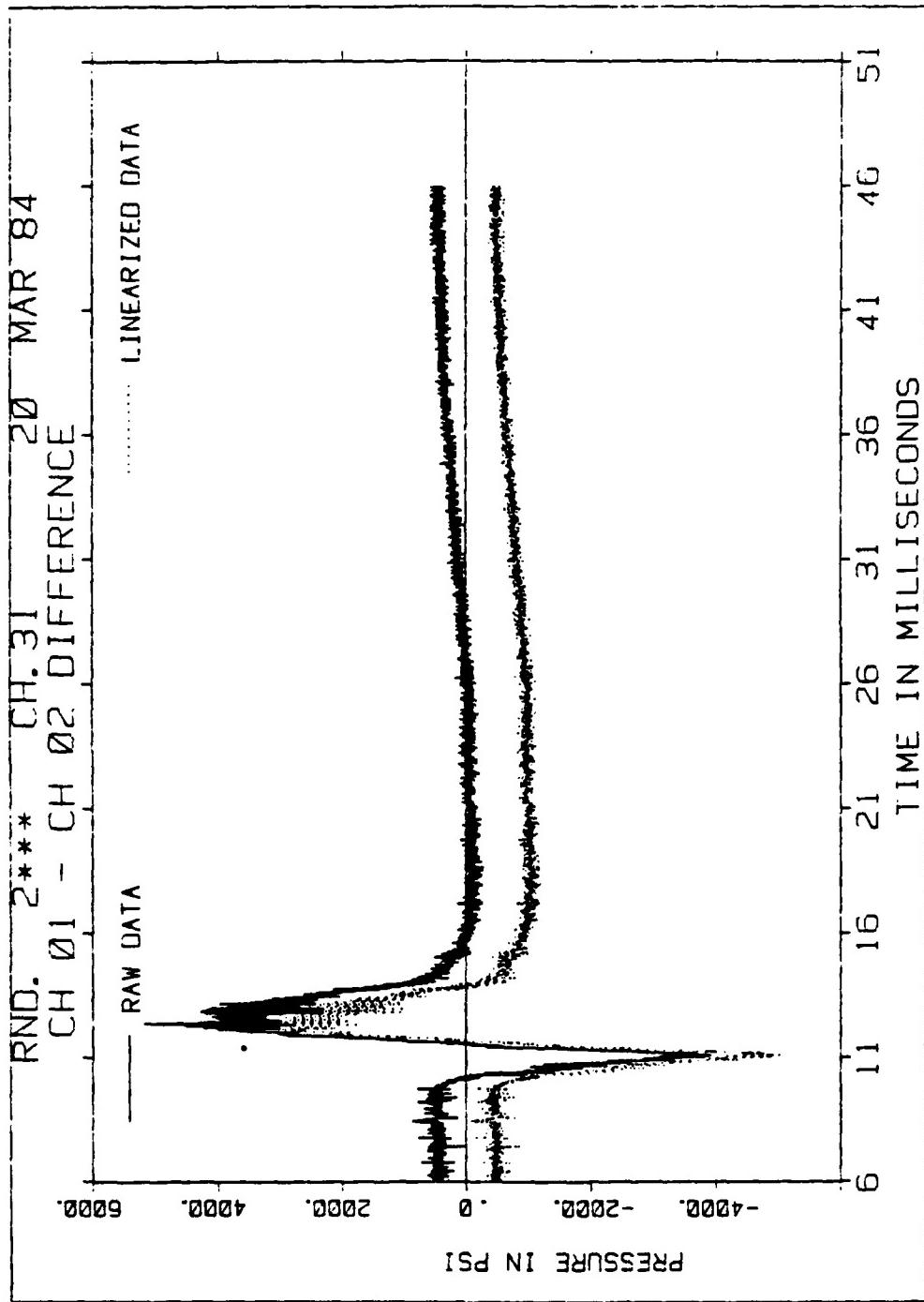


Figure 2.10-1. Raw and linearized differential data records.

Note that both records have been intentionally shifted from the X axis to prevent raw data plotting on the linearized data.

## 2.11 DATA ACQUISITION EQUIPMENT CONSIDERATIONS

If the same signal is applied simultaneously to two channels of the data acquisition system, the resulting difference between the two channels would ideally be zero. However, due to the inherent accuracy of the equipment, equipment noise, and noise introduced by the differencing process, the difference will seldom be the ideal result. Reference 2 states the accuracy of the data acquisition equipment as 0.2%. Thus, differencing two channels could result in errors as large as 0.4% from the data acquisition equipment alone. Whether an error of this magnitude is encountered in practice depends upon whether the equipment is matched closely or not.

Figure 2.11-1 is a plot of the difference obtained from two channels which had the same pulse input signal applied along with a plot of the input signal. The peak error in the difference is 0.5%. Equally disturbing, the difference curve is not symmetrical indicating a bias or nonlinearity in the data acquisition equipment. Elimination of the mismatch between the two channels was accomplished by swapping the signal conditioner, filter/amplifier and digitizer circuit cards one at a time then repeating the test until the offending device was found. At this point substitution of a new circuit card with one of the suspected device cards was carried out until an improved match was found. Figure 2.11-2 is a plot showing the difference after the mismatched circuit card was located. The peak error in the difference has been reduced to 0.3% and the difference curve is now symmetrical.

This example shows the desirability of checking the match in the data acquisition equipment when difference data are required. Details of the procedure used are in Appendix B.

(Cont'd)

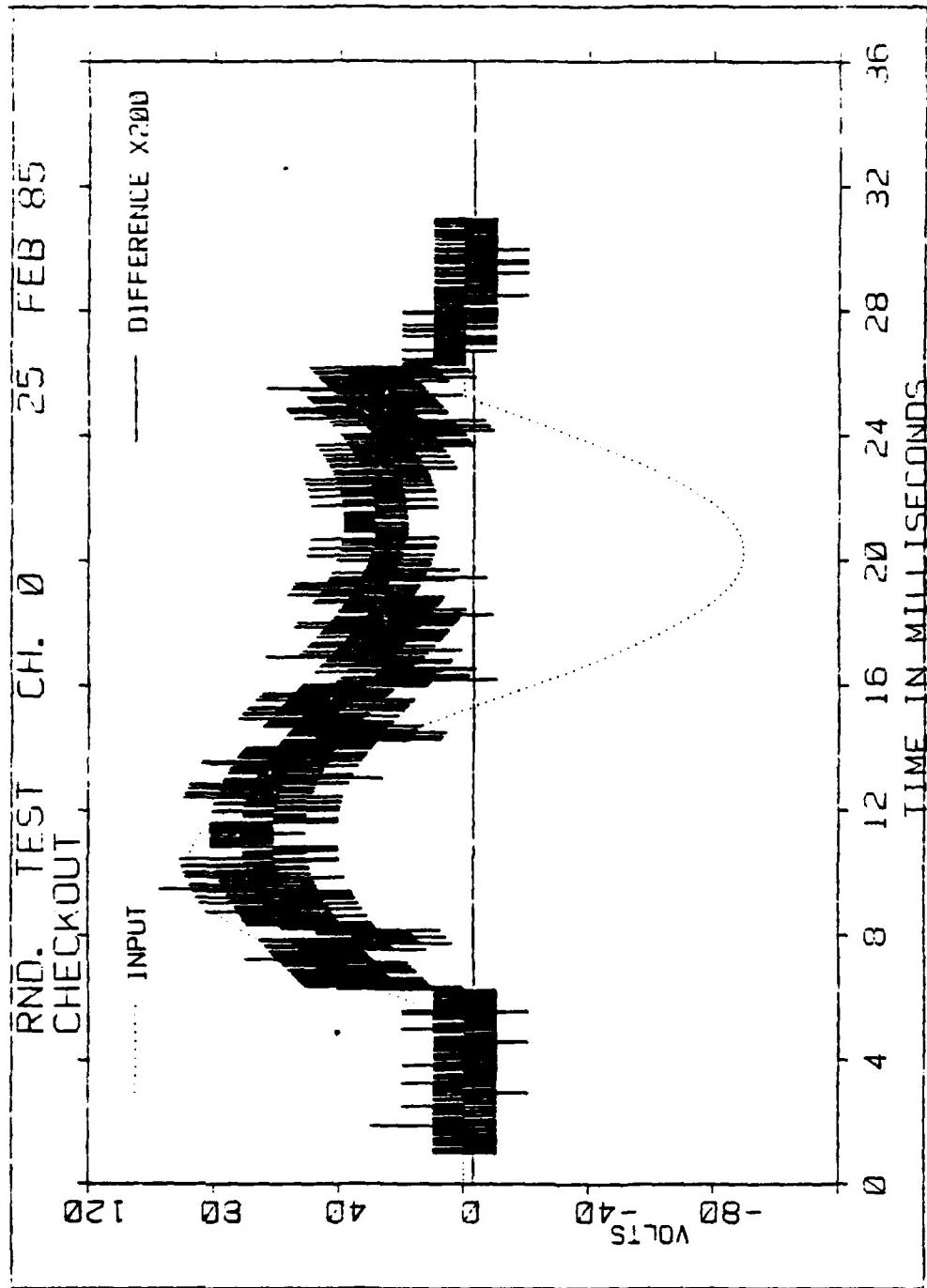


Figure 2.11-1. Difference observed when an identical input signal is applied to two unmatched channels.

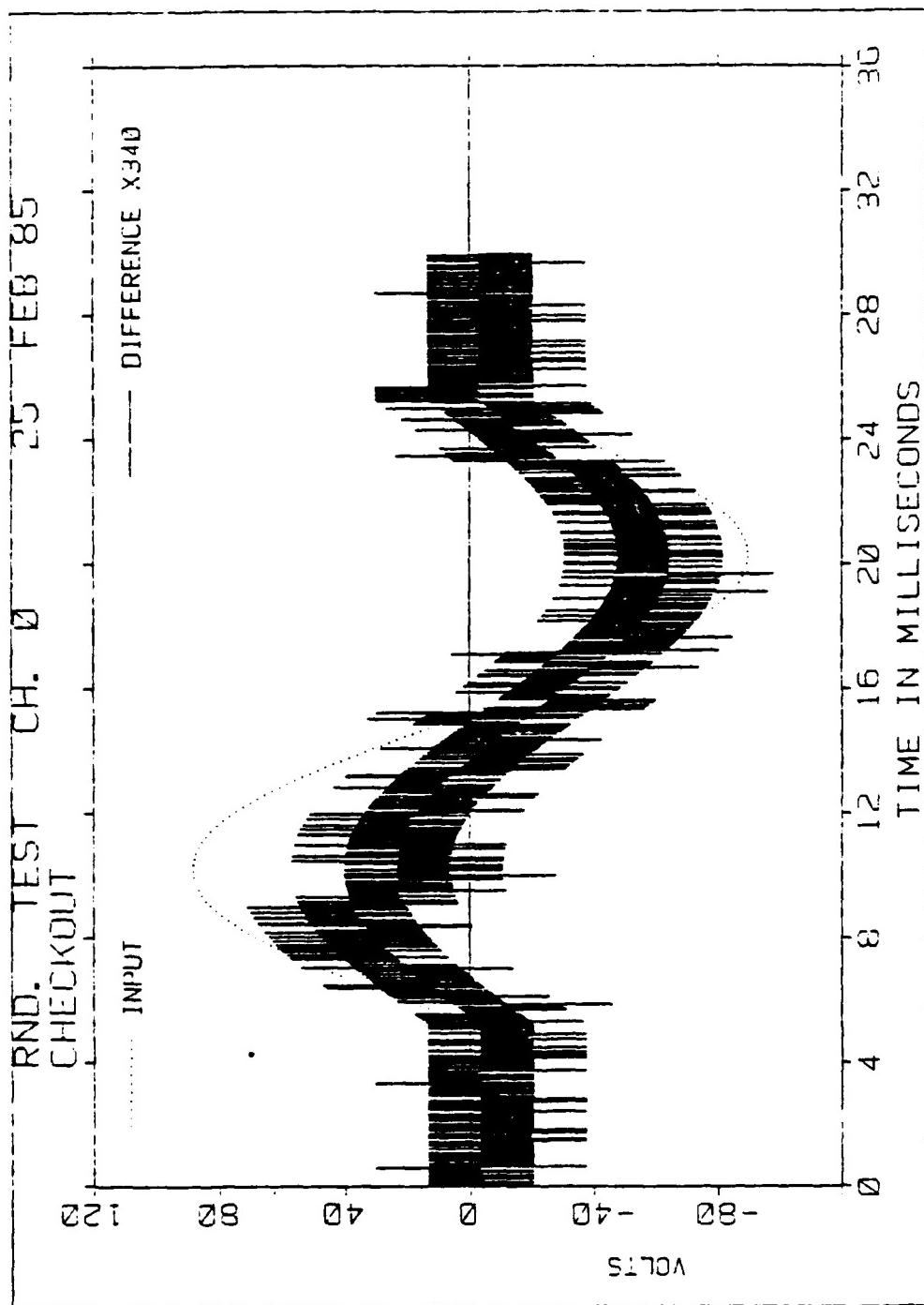


Figure 2.11-2. Difference observed when an identical input signal is applied to two reasonably matched channels.

## 2.12 DESCRIPTION OF TRANSDUCERS

a. Kistler 6211. The Kistler 6211 is a commercially manufactured high pressure quartz transducer. Its nominal scale factor is 8 psi/pcb, and its maximum range is 107,000 psi. It is installed using a metric 10 x 1 thread. It seals with a uniquely shaped sealing ring in conjunction with a reverse tapered sealing shoulder on the transducer.

Several pairs of Kistler 6211 transducers were used. It should be noted that No. 151647 and 151652 had performed poorly in the past and that No. 168650 and 168659 had performed very well in the past.

b. T-8M. The T-8M transducer shown in Figures 2.12-1 and 2.12-2 was designed by Welton Phillips of Yuma Proving Ground. It has an encapsulated tourmaline sensing element and is installed using a 1-1/8-12 thread. Its nominal scale factor is 1 psi/pcb. It has a needle valve which allows replenishing the grease around the sensing element without having to remove the gage from the weapon and electrical isolation of the element from the weapon to eliminate ground loop problems. This transducer has been tested up to 110,000 psi.

The two transducers used in this study utilized a double crystal design which provides double the normal output (scale factor = 0.5 psi/pcb). When compared to the standard single crystal design, the double crystal has been shown in Reference 1, Appendix D, to exhibit larger nonlinearity.

c. E15M. The E15M transducer was developed by Welton Phillips specifically for measuring chamber pressure in the 120-mm tank gun (ref 6, app D). It uses an encapsulated tourmaline crystal and is installed using a 1/2-20 thread. Its nominal scale factor is 1.5 psi/pcb, and it has been tested up to 120,000 psi. The sensing element is electrically isolated from ground. The seal uses a slight reverse taper on the transducer body.

A drawing of the E15M is shown in Figure 2.12-3.

d. E15MA. The E15MA transducer is identical to the E15M with two exceptions:

(1) The transducer output is available at the end of a 50 inch microdot cable. This feature eliminates connection on the transducer body, which is a potential source of vibration problems.

(2) The threaded section of the body is shorter and can be installed in a continuously threaded hole using a small extended hex instead of the internal hex used on the E15M.

A drawing of the E15MA is shown in Figure 2.12-4.

2.13 (Cont'd)

A limited number of shots were fired using the laboratory pressure generator developed by Princeton Combustion Research Laboratory (PCRL). This device is described in Reference 1, Appendix D. It has pressure ports for two transducers.

Figure 2.13-4 shows the results from the T-8M transducers. Note that differential pressure is rather large, predominately positive, and has a strange dip to zero in the middle.

Figure 2.13-5 shows the results from ES15M transducers. Note the oscillation of the differential pressure after the main pressure pulse. It is assumed that this oscillation is due to cable whip.

Figures 2.13-6 and 2.13-7 show the results of two pairs of Kistler 6211 transducers. Note that the oscillation of the differential pressure is larger yet, presumably because the lower output of these transducers makes the cable whip problem more apparent.

13 (Cont'd)

TABLE 2.13-3. SENSITIVITY SPREAD DURING CALIBRATION FROM  
5,000 TO 105,000 PSI EXPRESSED AS PERCENT  
OF MEAN SENSITIVITY

Transducer	Sensitivity Spread (% of Mean)
Kistler 6211 No. 151647	9.9
Kistler 6211 No. 151650	5.7
Kistler 6211 No. 151652	4.0
Kistler 6211 No. 151653	9.0
Kistler 6211 No. 168650	3.3
Kistler 6211 No. 168653	2.5
Kistler 6211 No. 168658	0.8
Kistler 6211 No. 168659	3.4
YPG ES15M No. 8	2.5
YPG T-8M No. 50	2.7
YPG T-8M No. 51	12.5

The instrumentation console used for calibration contains Kistler Model 504 charge amplifiers, which have a very long time constant. The charge amplifier used in field firing is a Precision Filter Model 316 which has a much shorter time constant. After calibration, some experiments were conducted to investigate the effect of the short time constant.

Figure 2.13-1 illustrates the output of two pressure transducers when pressure is released on the dead weight pressure balance. This output is plotted using the balance pressure as a baseline, hence the output is labeled as a negative value. Figure 2.13-1 was obtained using 504 charge amplifiers. Note that one transducer is 0.76% beyond the actual value and one transducer is .65% less than the actual value. Also note that both outputs are flat after pressure release.

Figure 2.13-2 shows a pressure release using the 316 charge amplifiers. Note that the output after release decays slowly back toward zero at a decay rate consistent with a 1.2 second time constant. Both transducers now produce less output than the actual pressure value. It is interesting to note that the spread between the two transducers has also increased.

Figure 2.13-3 compares an electrical step with a normal pressure release and a slow pressure release when using the 316 amplifier. Note that, as one would expect, the slower events have a larger error introduced by the short time constant.

The pressure pulse produced by a weapon is short, and the effect of the short time constant on field data should not be as dramatic. To investigate this effect, both the 316 and 504 charge amplifiers were used during the field firing phase.

TABLE 2.13-2. CALIBRATION REPORT OF KISTLER  
6211 TRANSDUCER NO. 151647

Note less linear response.

TRANSDUCER CALIBRATION REPORT # 84 LP-

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151647	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.308	-161	0.1207

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
.05	12693	6.31	0.121	288	0.27
.00	12088	6.01	0.121	268	0.27
.90	10860	5.40	0.121	60	0.07
.80	9646	4.80	0.121	-23	-0.03
.70	8427	4.19	0.120	-154	-0.22
.60	7205	7.17	0.120	-304	-0.51
.50	5990	5.97	0.120	-398	-0.80
.40	4790	4.77	0.120	-370	-0.92
.30	3608	7.15	0.120	-186	-0.62
.20	2434	4.82	0.122	63	0.31
.15	1842	9.14	0.123	145	0.97
.10	1257	6.21	0.126	286	2.86
.05	660	6.59	0.132	325	5.50

2.13 (Cont'd)

TABLE 2.13-1. CALIBRATION REPORT OF KISTLER  
6211 TRANSDUCER NO. 168658

Note extremely linear response of this transducer.

TRANSDUCER CALIBRATION REPORT # 84 LP-

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840810

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR  
KIST 6211 168658 MEF R. MILLER

\*DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
13 8.447 105 0.1181

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
.05	12458	6.20	0.119	340	0.32
.00	11837	5.89	0.118	94	0.09
.90	10630	5.29	0.118	-100	-0.11
.80	9446	4.71	0.118	-101	-0.13
.70	8261	4.11	0.118	-111	-0.16
.60	7070	7.05	0.118	-170	-0.28
.50	5887	5.87	0.118	-170	-0.34
.40	4705	4.69	0.118	-153	-0.38
.30	3539	7.02	0.118	1	0.00
.20	2363	4.69	0.118	67	0.34
.15	1771	8.79	0.118	65	0.43
.10	1137	5.87	0.119	130	1.30
.05	592	5.31	0.118	107	2.13

## 2.13 LABORATORY TESTING

The transducers were calibrated using a dead weight pressure balance and the signal conditioning instrumentation console described in Reference 1, Appendix D. Calibration was done at 13 pressure levels, varying from 5,000 to 105,000 psi.

A sample calibration report for Kistler 6211 transducer No. 168658 is shown in Table 2.13-1. This transducer exhibits very linear response. Note that the values in the SENS column are always 0.119 or 0.118 pcb/psi. The mean sensitivity is 0.1181 pcb/psi which is also the slope of the best straight line through zero (BSLZ). This value is used for calculating peak pressure and differential pressure levels during field testing.

Table 2.13-2 shows a calibration report for Kistler 6211 transducer No. 151647 which is much more nonlinear than the previous transducer. Note that the sensitivity varies from 0.120 to 0.132 pcb/psi. This spread represents 9.9% of the mean sensitivity ( $\frac{0.132 - 0.120}{0.120} = 0.099$ ). Table 2.13-3 lists the sensitivity spread for all the transducers that were calibrated from 5,000 to 105,000 psi. Not all transducers are included in Table 2.13-3. Because some transducers were received shortly before firing, only the calibration data supplied (from 30,000 to 80,000 psi) were available.

2.12 (Cont'd)

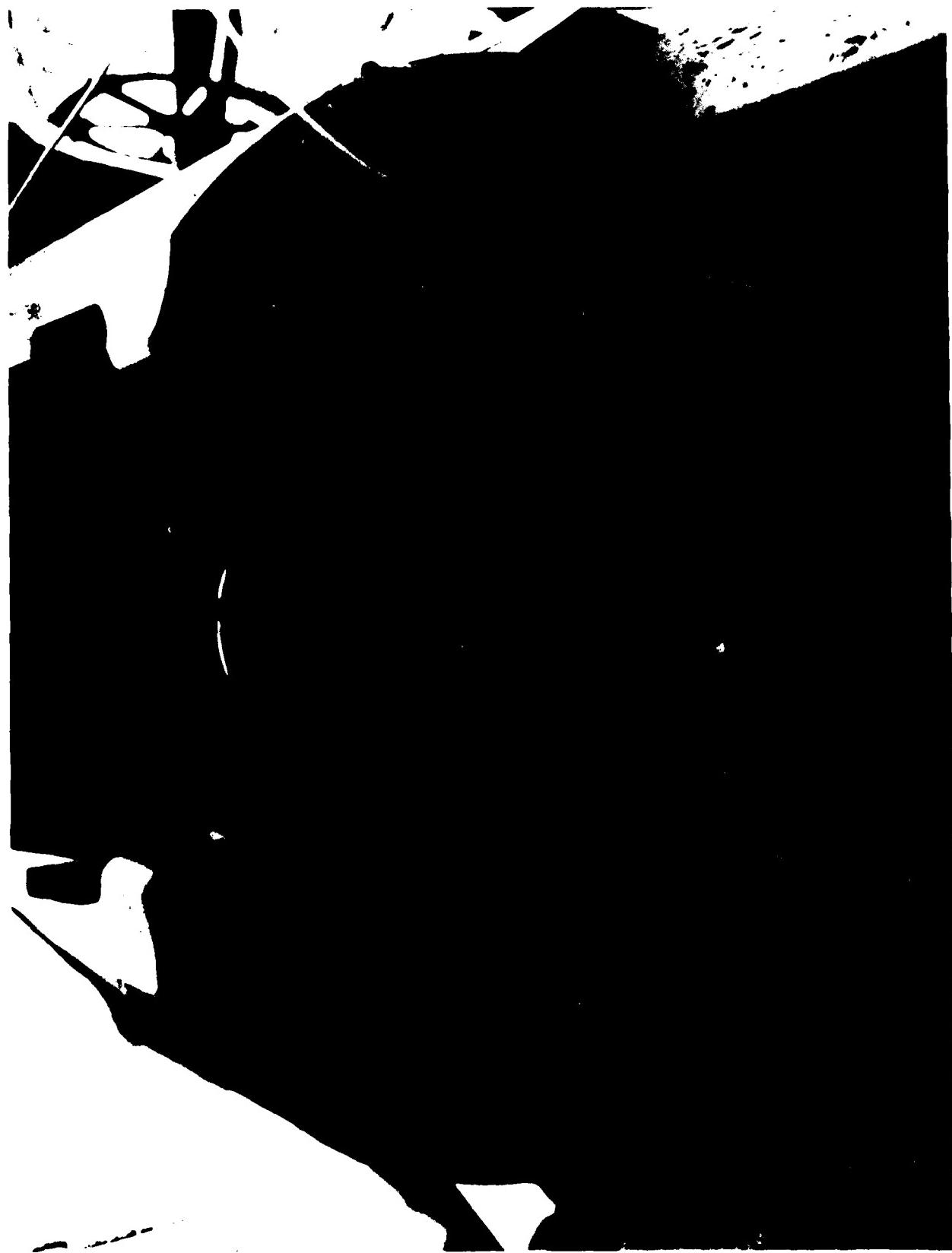
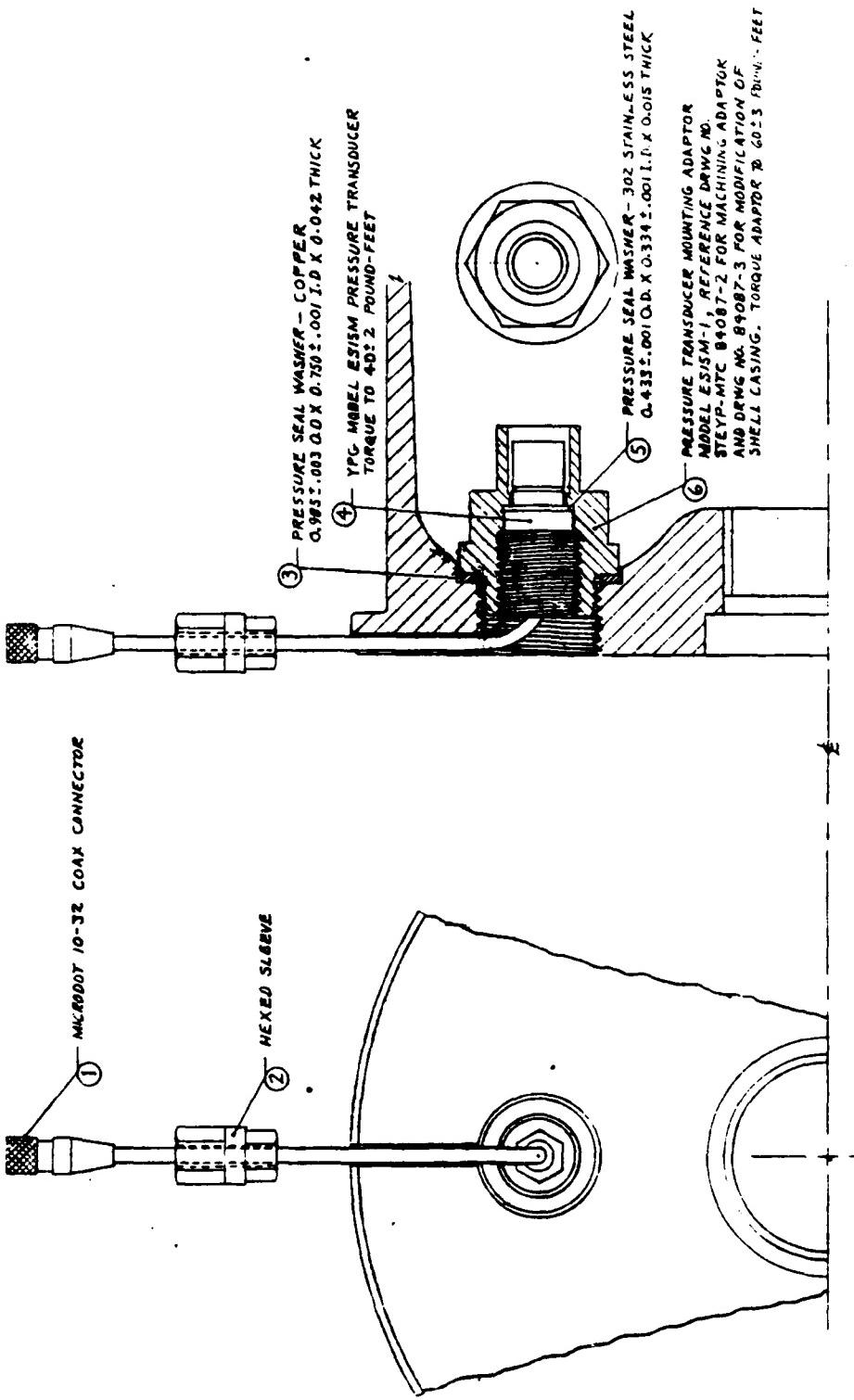


Figure 2.12-8. Photograph of model ES15M pressure transducer in base of cartridge case before firing.



INSTALLATION OF YUMA PROVING GROUND MODEL ES15M PRESSURE TRANSDUCER  
IN 105MM CASE CARTRIDGE M1+BA1B1 FOR MEASURING BREECH PRESSURE

YUMA PROVING GROUND, ARIZ
STEY-NTC
ENCL: Drawing C publication
CASE: 2/1
DATE: 27 MAR 1984
DRWG NO.: 84087-1

Figure 2.12-7. Installation drawing showing typical use of model ES15M pressure transducer in base of cartridge case.

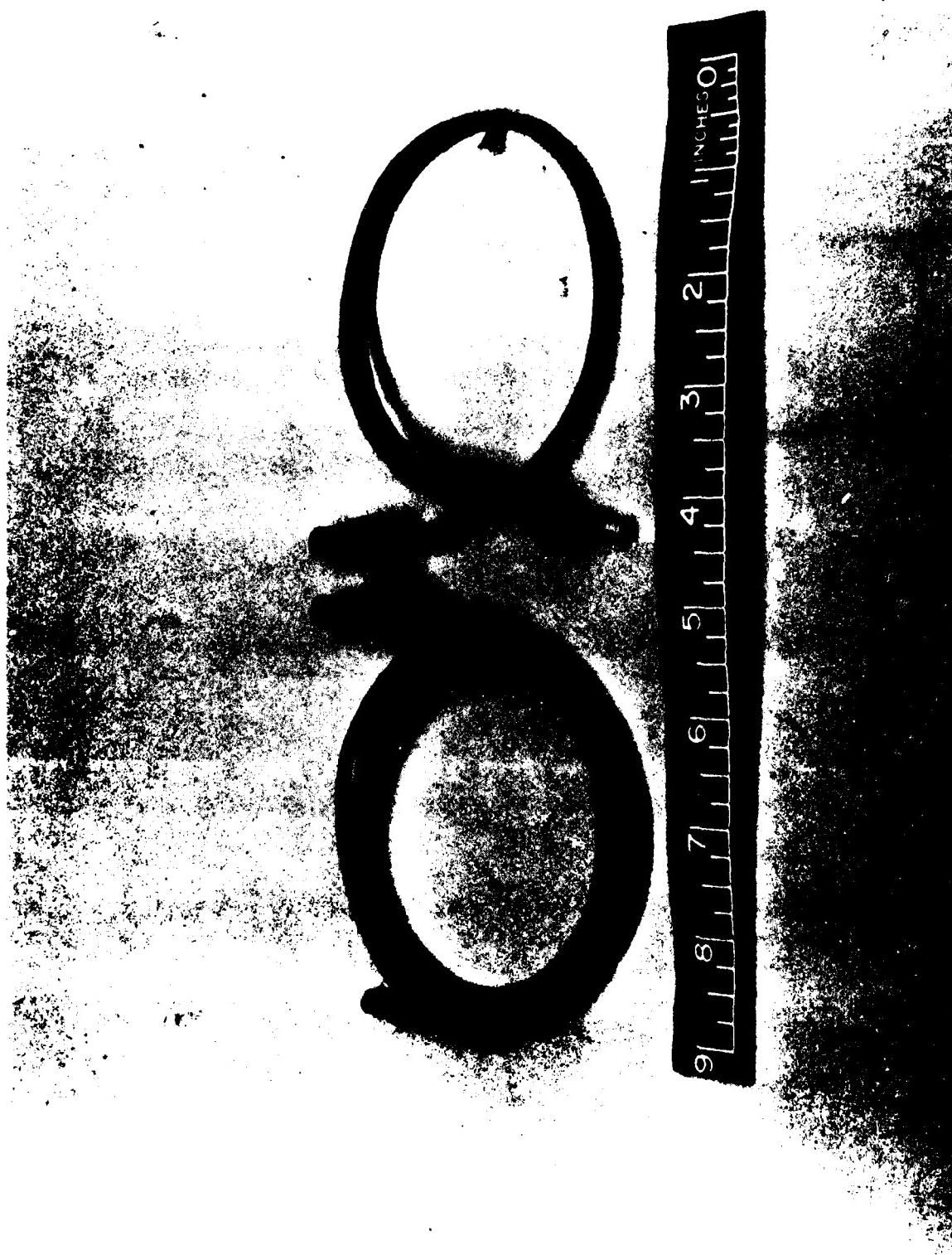


Figure 2.12-6. Photograph of two model ES15M pressure transducers.

2.12 (Cont'd)

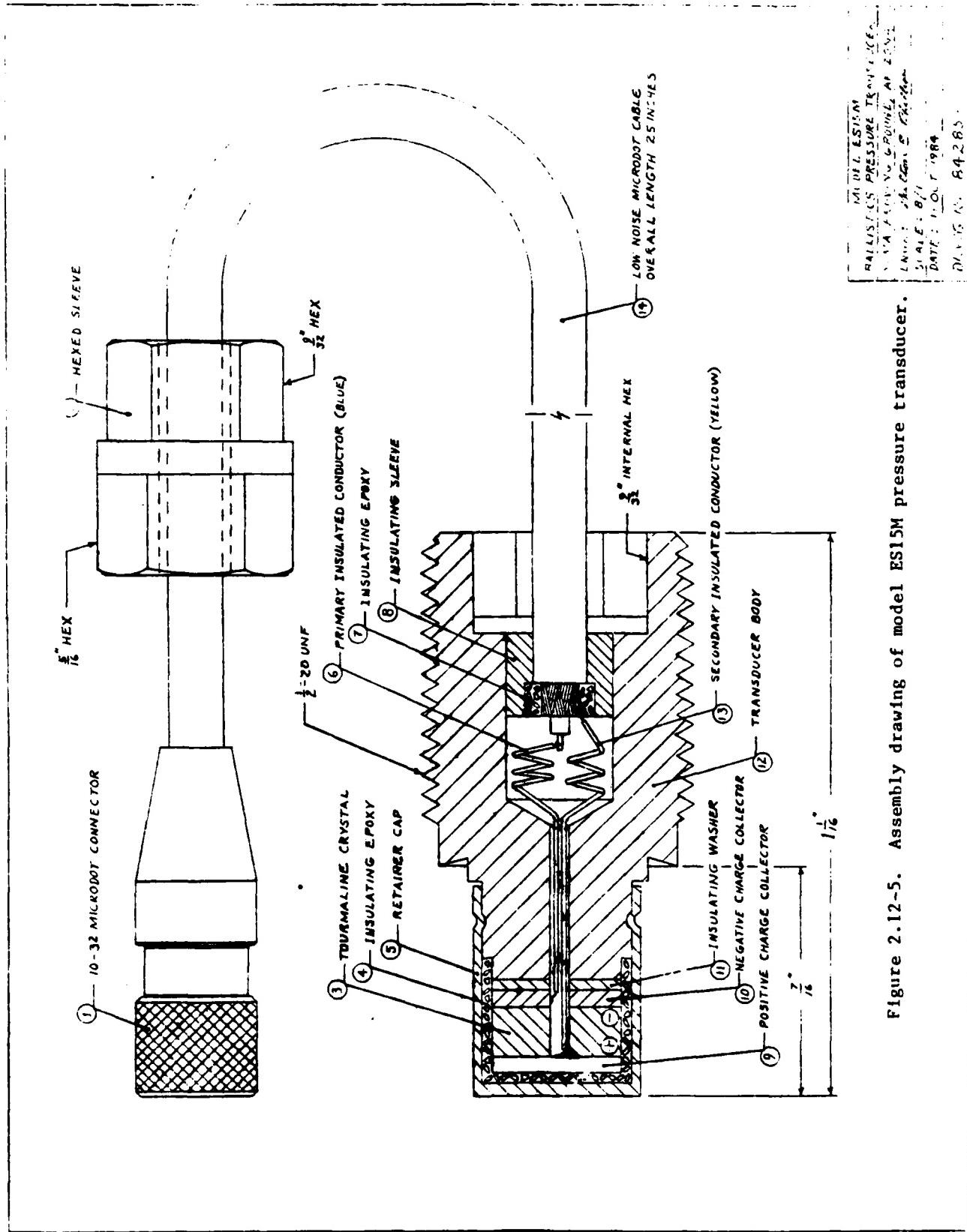


Figure 2.12-5. Assembly drawing of model ES15M pressure transducer.

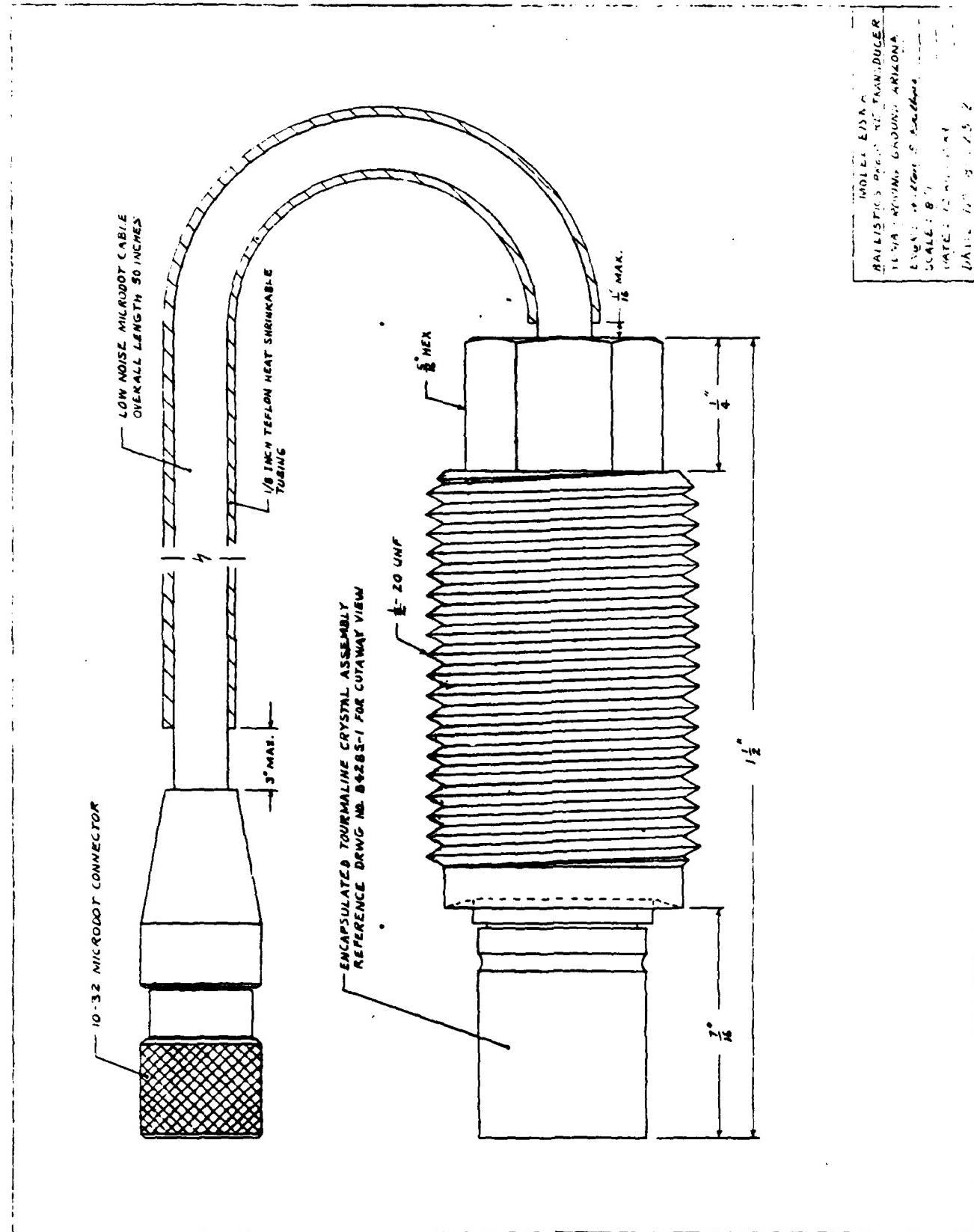


Figure 2.12-4. Assembly drawing of model E15MA pressure transducer.

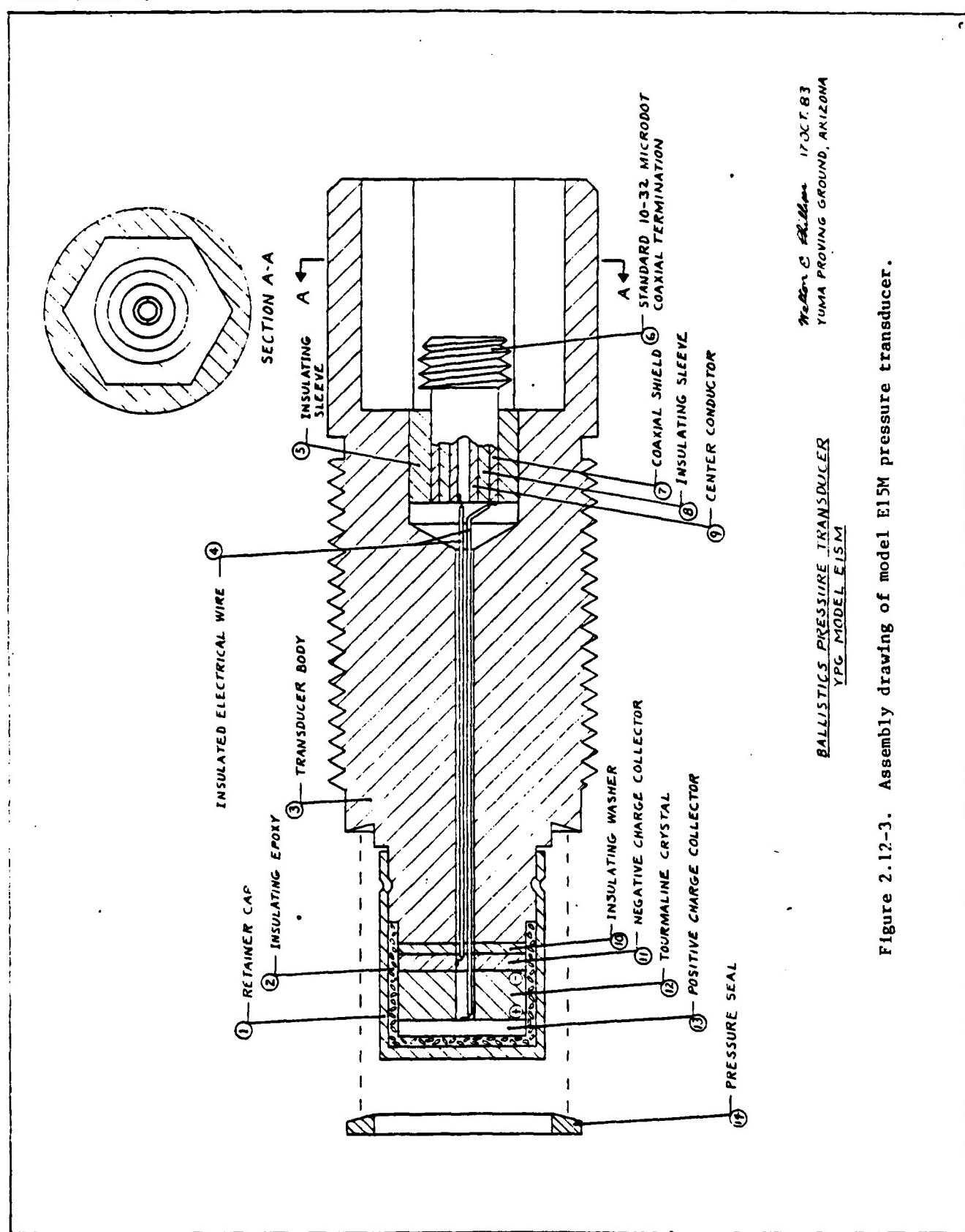
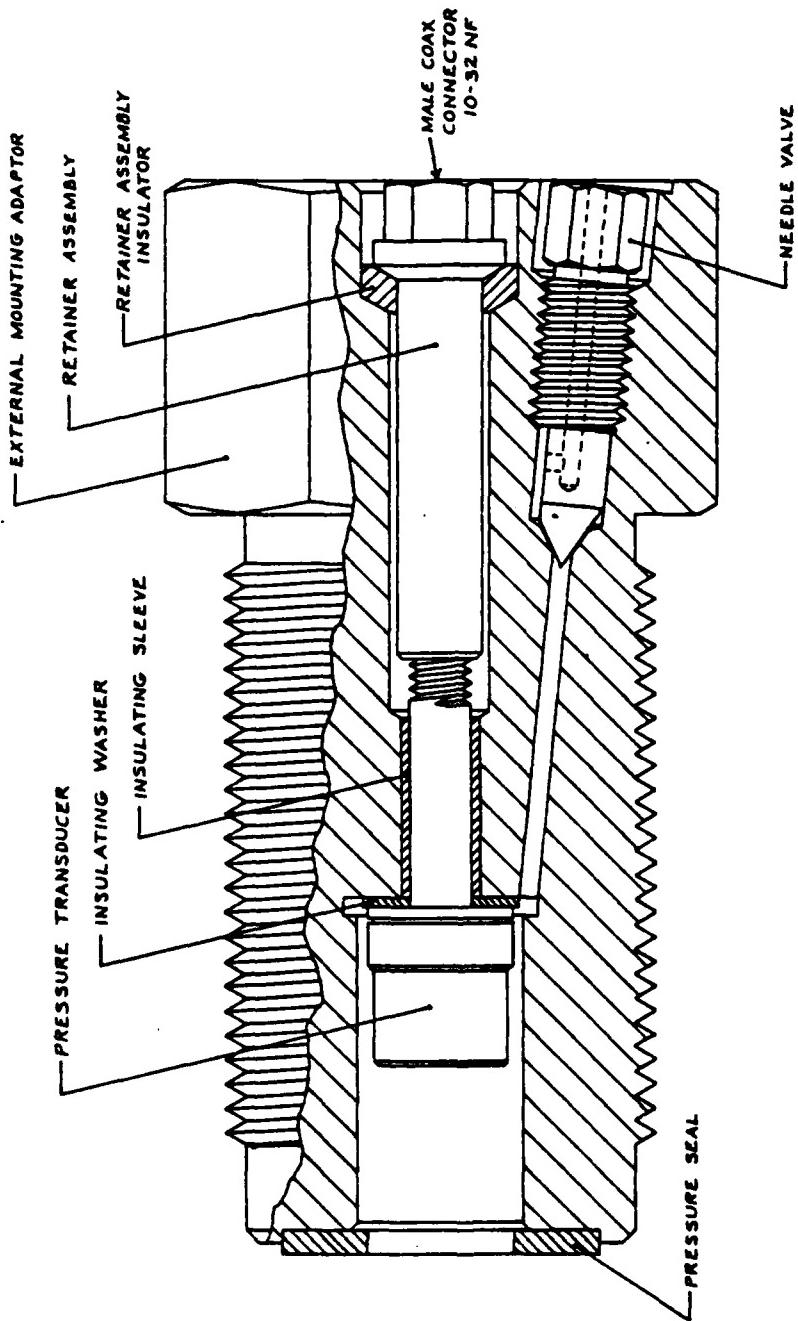


Figure 2.12-3. Assembly drawing of model E15M pressure transducer.

2.12 (Cont'd)



Figure 2.12-2. Photograph of T-8M pressure transducer (disassembled) and grease application tool.



YUMA PROVING GROUND, ARIZONA STRP-MTC	SCALE: NONE
PRESSURE TRANSDUCER ASSEMBLY	DATE: 2 NOV. 1981
MODEL T-RM	ENGR: <i>[Signature]</i>
DRWG. NO. 81306-1	

Figure 2.12-1. Assembly drawing of the model T-RM pressure transducer.

2.12 (Cont'd)

e. ES15M. The ES15M transducer uses the same encapsulated tourmaline sensing element as the E15M and E15MA transducers. This gage has the shortest threaded length of the three transducers, and is particularly well suited for installation in the base of cartridge cases. The thread and sealing surface of the E15M, E15MA, and ES15M are all the same so that all three transducers will fit in the same hole.

A diagram of the ES15M is shown in Figure 2.12-5. A photograph of the ES15M is shown in Figure 2.12-6. A drawing of a typical ES15M installation is shown in Figure 2.12-7, and a photograph of a typical installation in Figure 2.12-8.

2.13 (Cont'd)

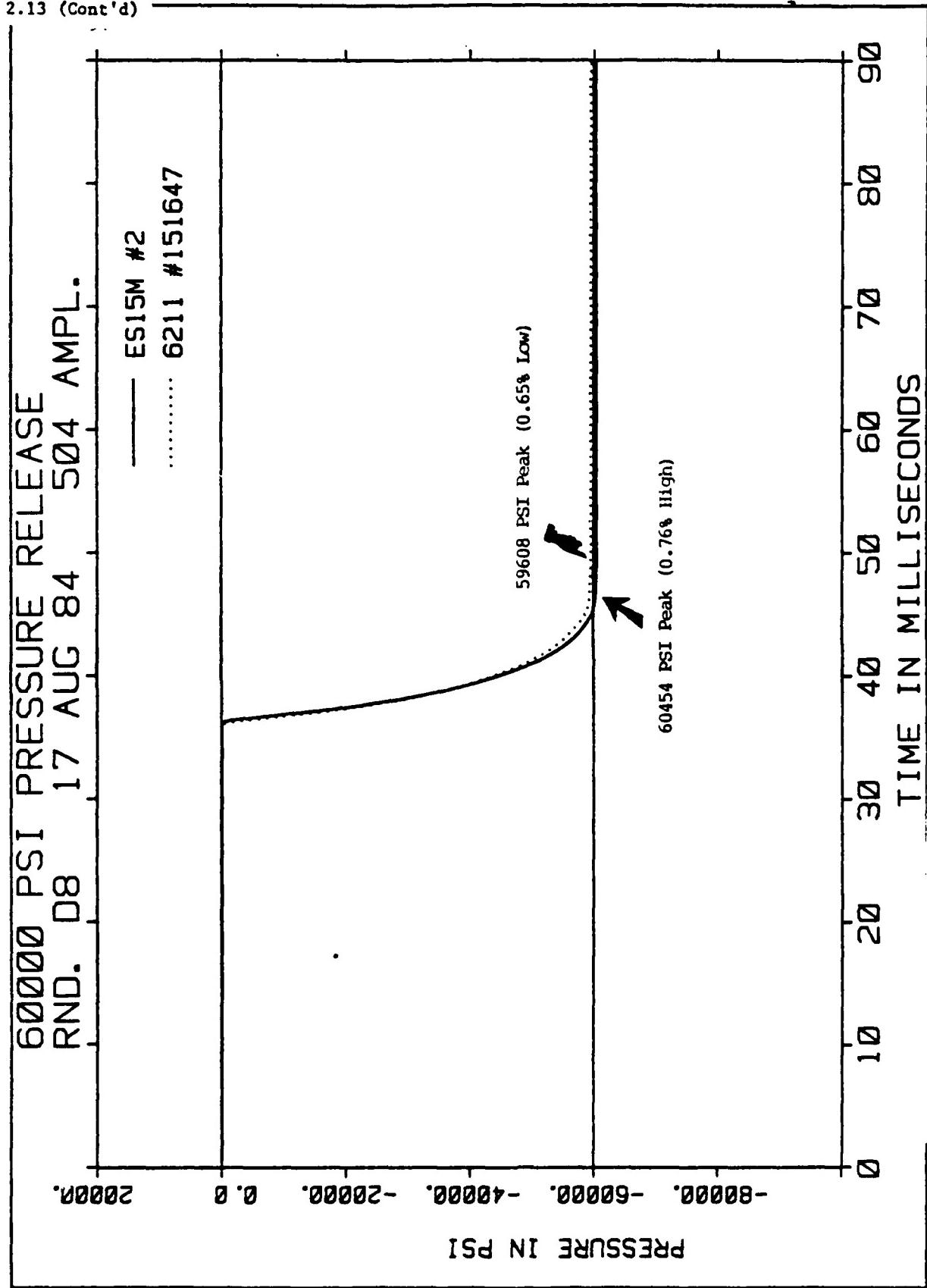


Figure 2.13-1. Response of two transducers to pressure release on dead weight pressure balance. Note that the Kistler model 504 charge amplifier has almost DC response.

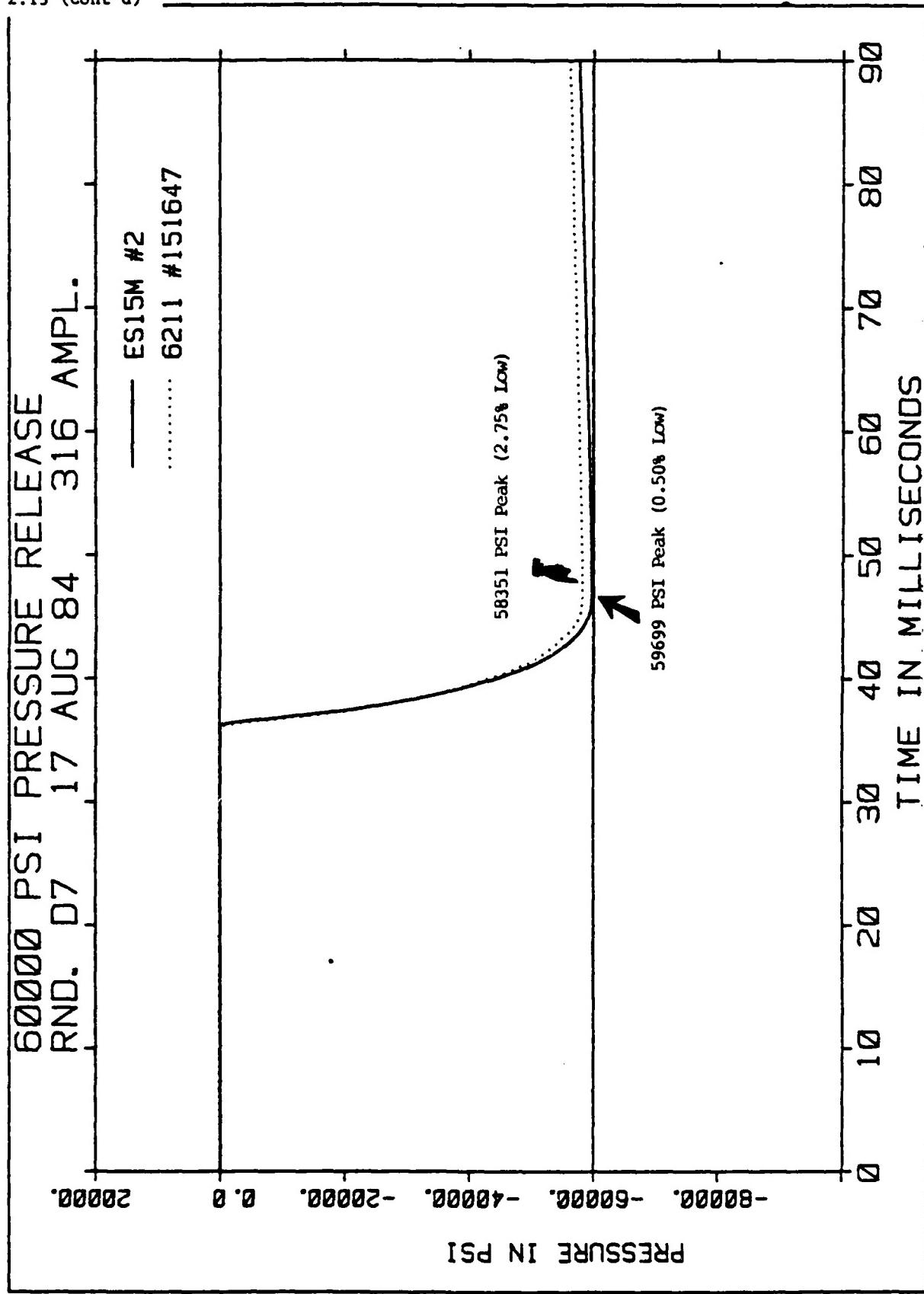


Figure 2.13-2. Response of two transducers to 60,000 psi pressure release. Note that the short time constant of the Precision Filters model 316 charge amplifier causes the output of both transducers to read low.

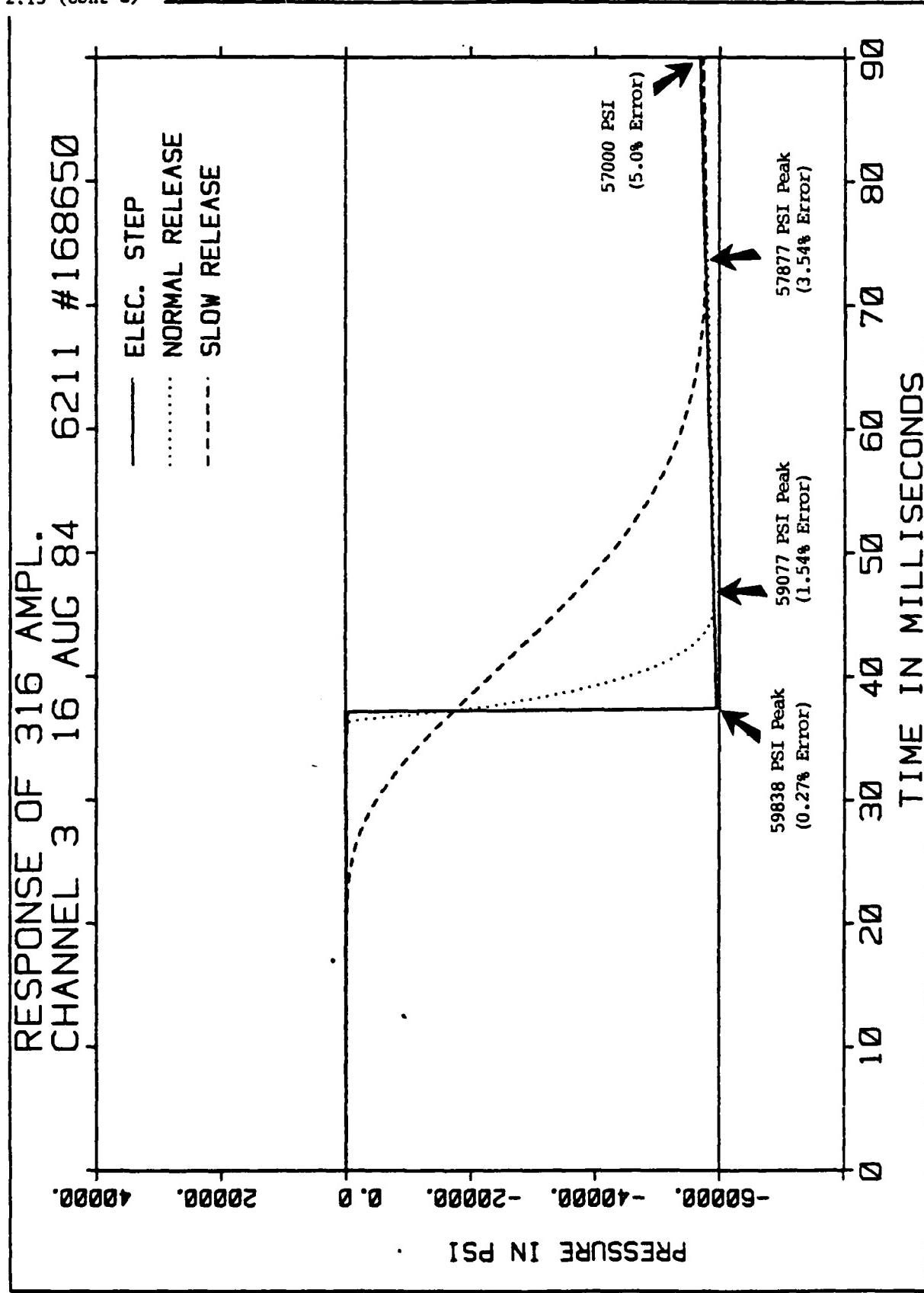


Figure 2.13-3. Response of the model 316 charge amplifier to various signals.

2.13 (Cont'd)

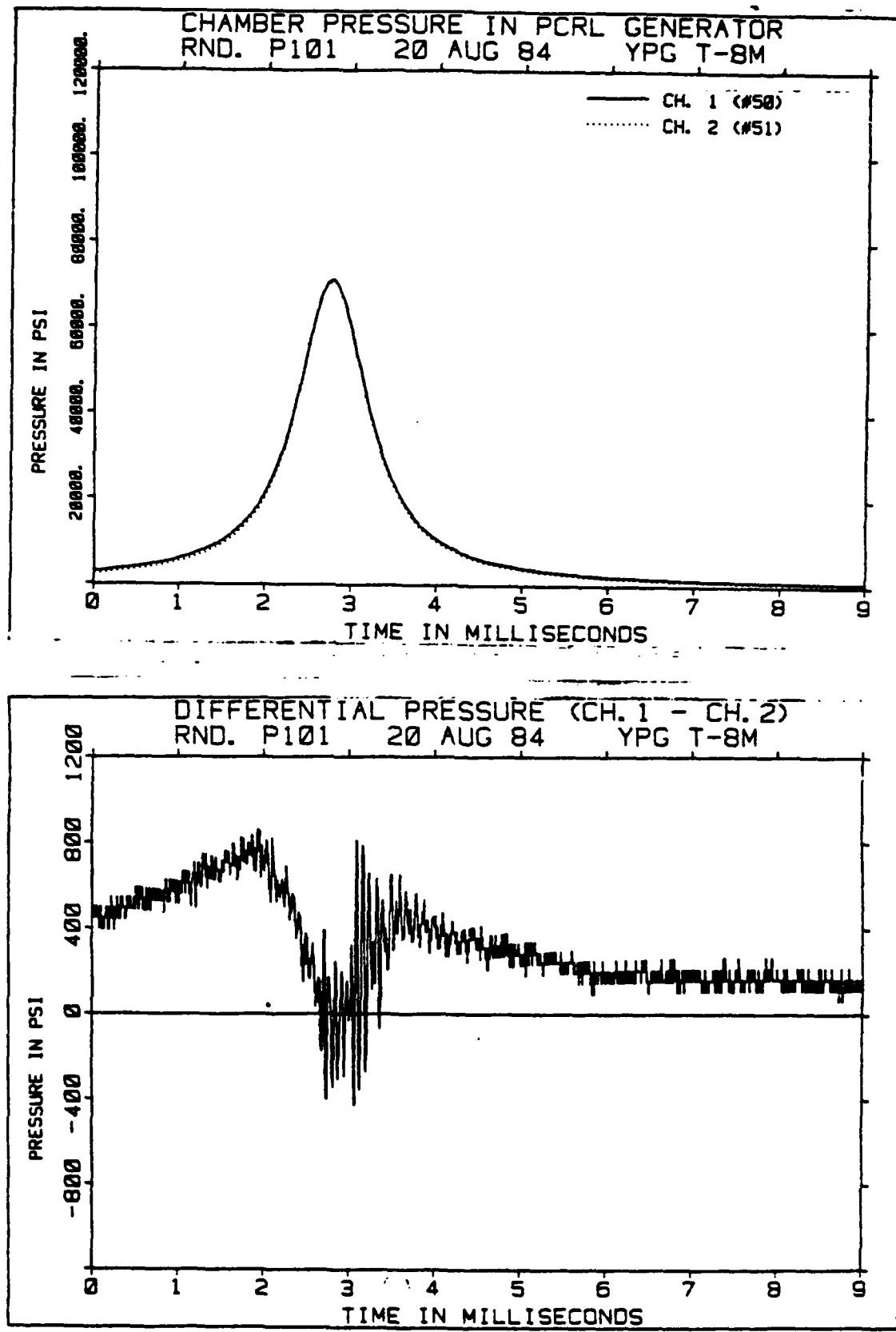


Figure 2.13-4. Pressure measurement from PCRL pressure generator using T-8M transducers.

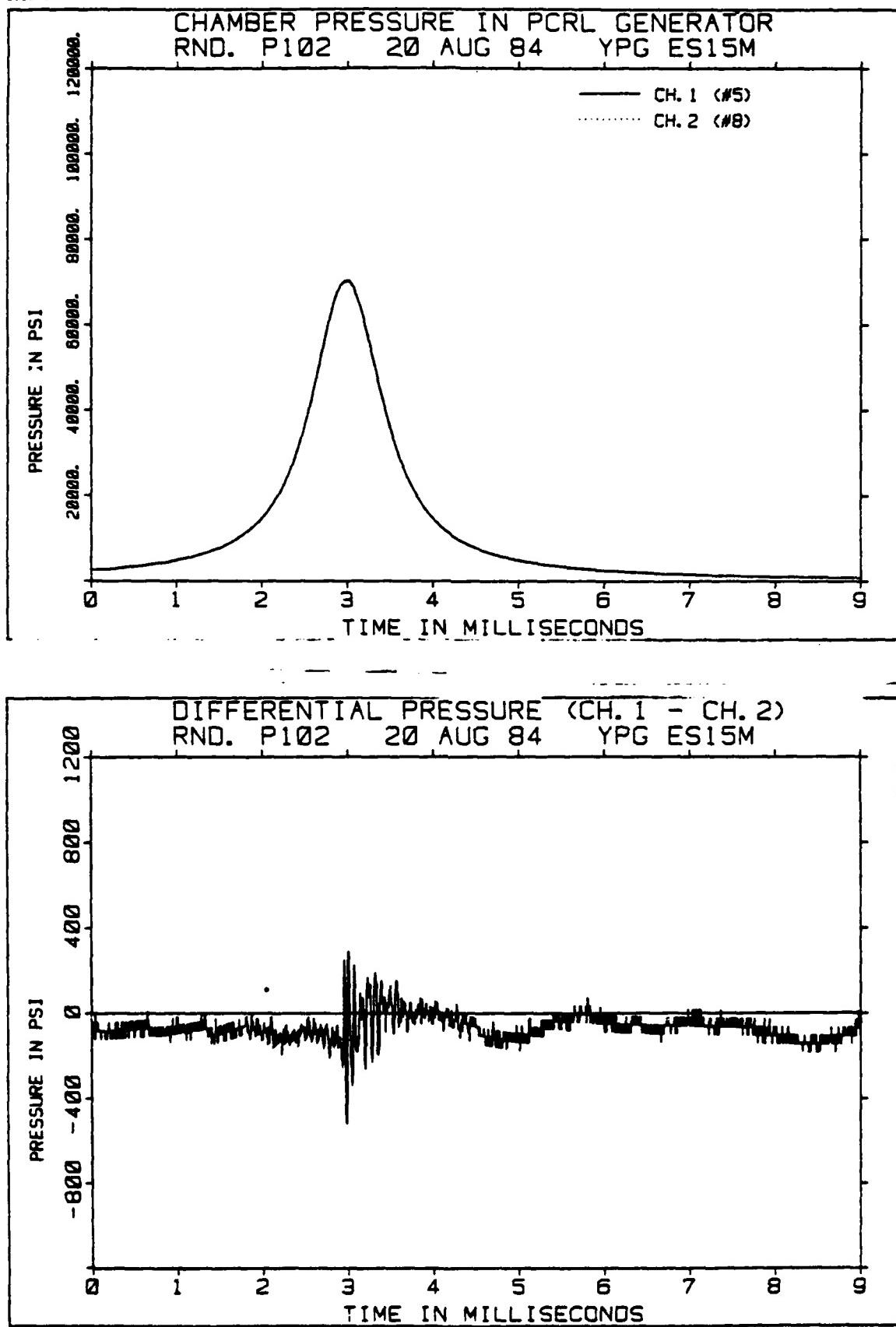


Figure 2.13-5. Pressure measurement from PCRL pressure generator using ES15M transducers.

2.13 (Cont'd)

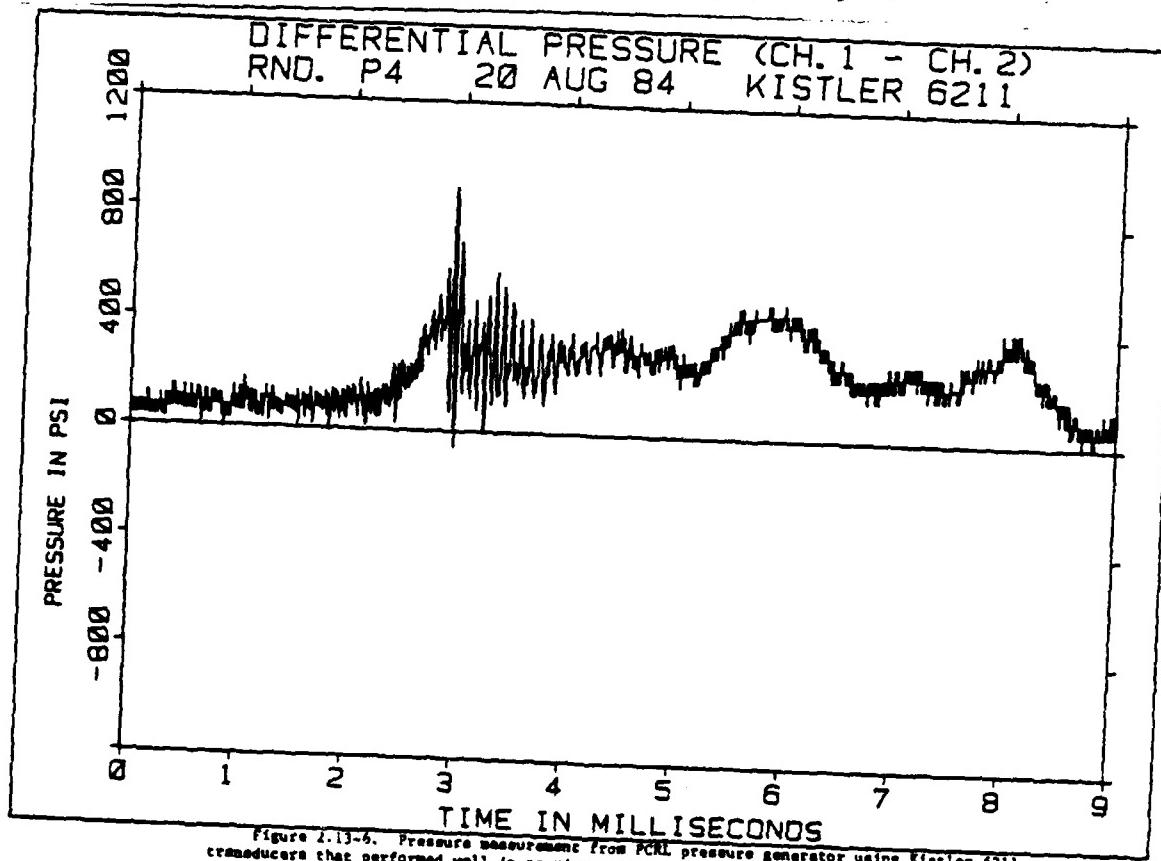
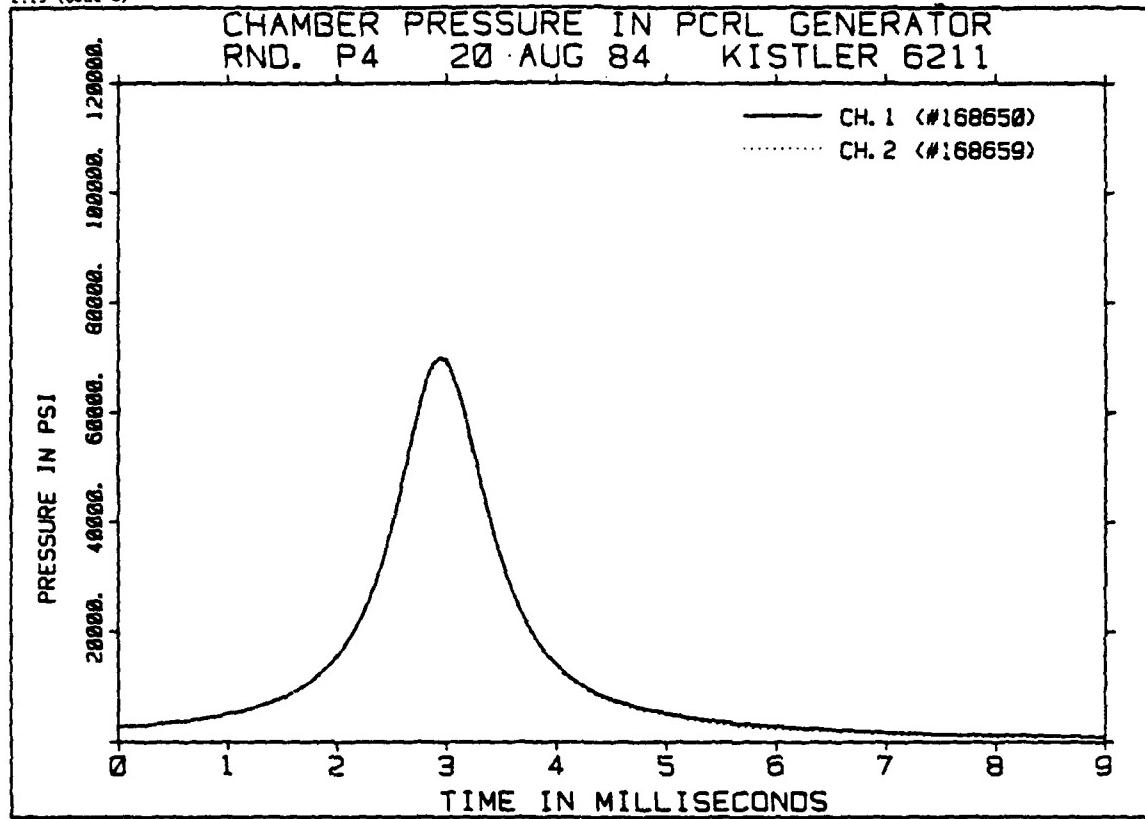


Figure 2.13-6. Pressure measurement from PCRL pressure generator using Kistler 6211 transducers that performed well in previous tests.

2.13 (Cont'd)

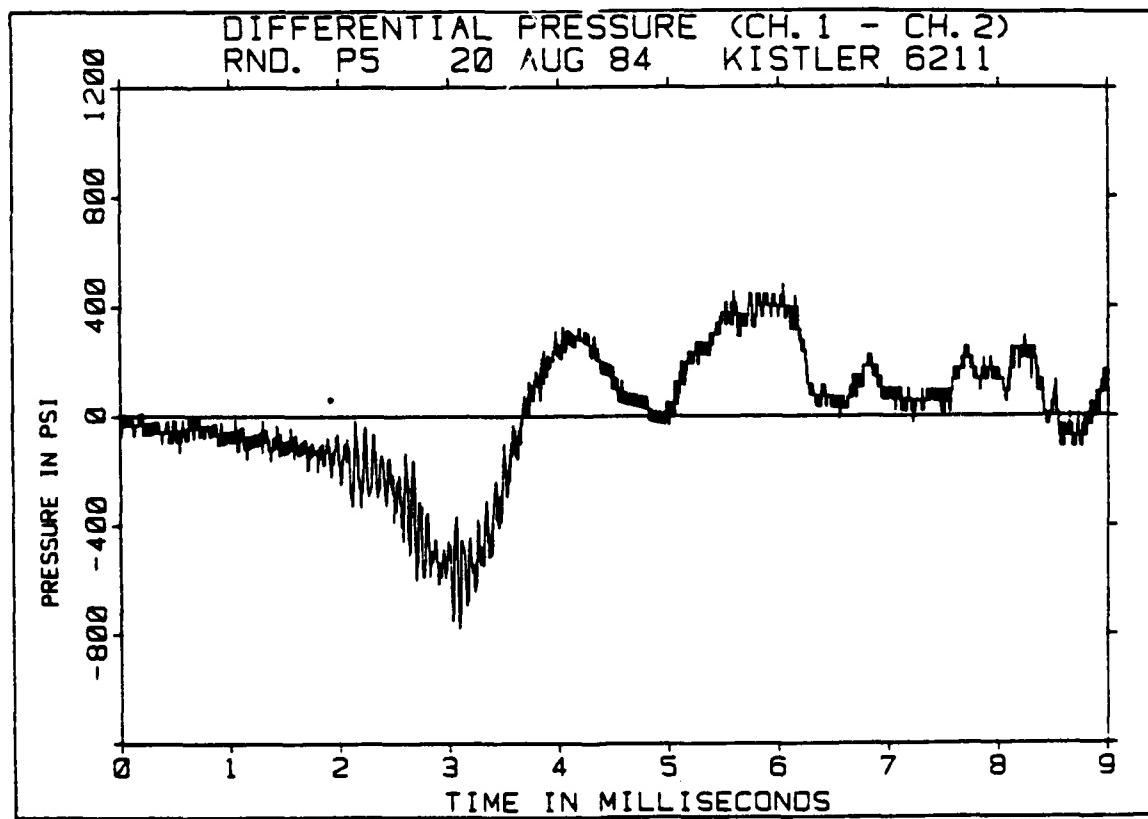
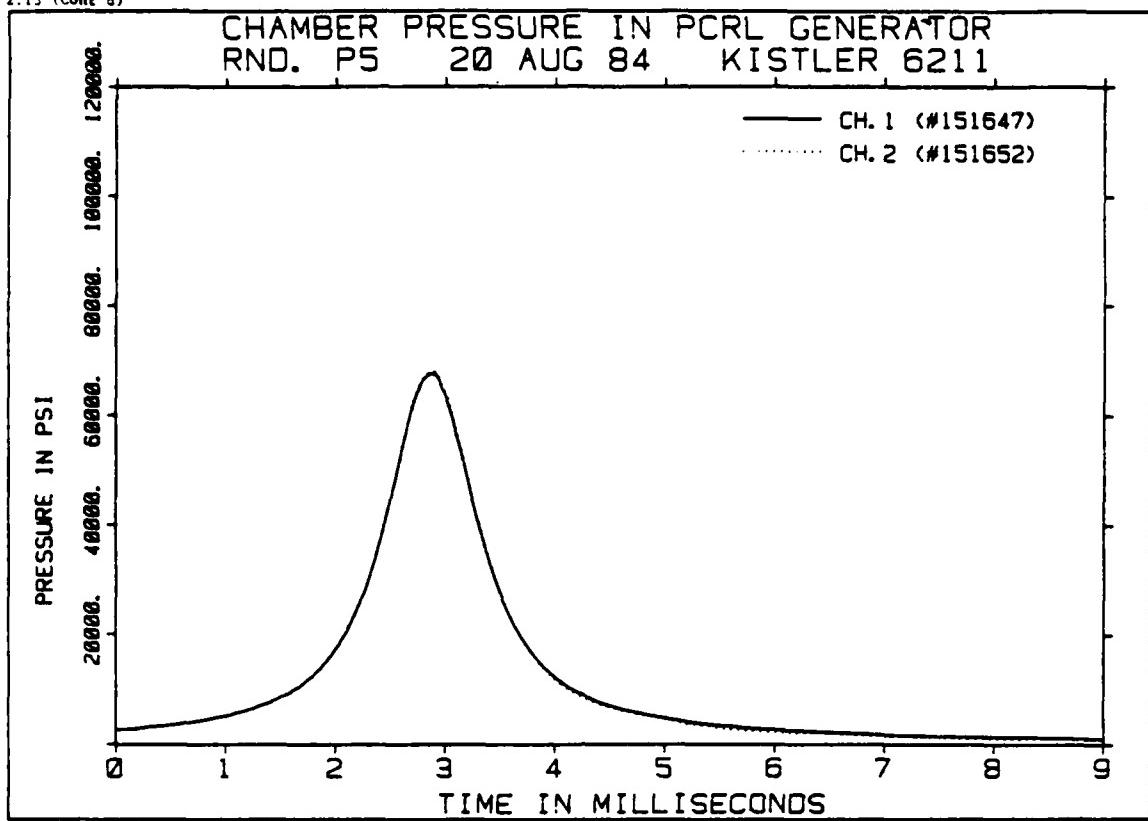


Figure 2.13-7. Pressure measurement from PCRL pressure generator using Kistler 6211 transducers that performed poorly in previous tests.

APPENDIX A - METHODOLOGY INVESTIGATION AND PROPOSAL



DEPARTMENT OF THE ARMY Mr. Gehrig/brt/AUTOVON  
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND 283-3677  
ABERDEEN PROVING GROUND, MARYLAND 21005

REPLY TO  
ATTENTION OF  
DRSTE-AD-M

25 MAY 1984

SUBJECT: RDTE Methodology Improvement Program Directive, 120mm  
Differential Weapon Chamber Pressure Measurement, TECOM  
Project No. 7-CO-RD4-APO-014 + 177-1

Commander  
US Army Aberdeen Proving Ground  
ATTN: STEAP-MT-M  
Aberdeen Proving Ground, MD 21005

1. Reference TECOM Regulation 70-12, dated 1 June 1983.
2. This letter constitutes a directive for the subject investigation under the TECOM Methodology Improvement Program 1W665702D625.
3. The MIP at Enclosure 1 is the basis for headquarters approval of the subject investigation.
4. Special Instructions:
  - a. All reporting will be consonance with paragraph 9 of the reference. The final report, when applicable, will be submitted to this headquarters, ATTN: DRSTE-AD-M, in consonance with Test Event 570/580. Each project shall have a phase/project completion in FY84 which is reflected in the scheduling.
  - b. Recommendations for new TOPs or revisions to existing TOPs will be included as part of the recommendation section of the final report. Final decision on the scope of the TOP effort will be made by this headquarters as part of the report approval process.
  - c. The addressee will determine whether any classified information is involved, and will assure that proper security measures are taken when appropriate.. All OPSEC guidance will be strictly followed during this investigation.
  - d. Prior to test execution, the test activity will verify that no safety or potential health hazards to humans participating in testing exist. If safety or health hazards do exist, the test activity will provide a safety/health hazards assessment statement to this office prior to test initiation.
  - e. Environmental documentation for support tests or special studies is the responsibility of the test activity and will be accomplished prior to initiation of the investigation/study.

A-1

RFI- 394-0348

25 MAY 1981

DRSTE-AD-M

SUBJECT: RDTE Methodology Improvement Program Directive, 120mm  
Differential Weapon Chamber Pressure Measurement, TECOM  
Project No. 7-CO-RD4-APO-014

f. Upon receipt of this directive, test milestone schedules as established in TRMS II data base will be reviewed in light of other known workload and projected available resources. If rescheduling is necessary and the sponsor nonconcurs, a letter citing particulars, together with recommendations, will be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, with an information copy to DRSTE-TO-0, no later than 15 calendar days from the date of this letter. Reschedules concurred in by the sponsor can be entered directly along with a properly coded narrative by your installation/test activity.

g. The HQ TECOM point of contact is Mr. John Gehrig, DRSTE-AD-M, AUTOVON 283-2170/2375.

h. FY84 RDTE funds in the amount of \$10,000 have been authorized for this investigation; DARCOM Form 1006 will be forwarded by the Comptroller.

FOR THE COMMANDER:



1 Encl  
as

GROVER H. SHELTON  
C, Meth Imprv Div  
Analysis Directorate

April 1984

RDTE METHODOLOGY INVESTIGATION PROPOSAL FY 84

1. TITLE. 120mm Differential Weapon Chamber Pressure Measurement
2. CATEGORY. Thrust Area IIIc
3. INSTALLATION. Materiel Testing Directorate  
US Army Aberdeen Proving Ground  
Aberdeen Proving Ground, MD 21005
4. PRINCIPAL INVESTIGATORS. V. A. Betzold (AV 283-2208)  
W. S. Walton (AV 283-2313)  
Measurements and Analysis Division  
STEAP-MT-G
5. STATEMENT OF THE PROBLEM. The measurement of differential chamber pressure is an essential factor in evaluation of ammunition performance. Recently, the validity of differential pressure measurements of 120mm ammunition has been in question. Failure to assure the validity of 120mm ammunition data may result in stopping ammunition production or in fielding unsafe ammunition.
6. BACKGROUND. W. S. Walton evaluated pressure gage performance in a report titled, Improved Standardized Weapon Chamber Pressure Measurement, TRMS No. 7-CO-MT9-AP1-001, dated April 1982. The report discusses the pressure measurement process, selection of transducers, installation, signal conditioning, and data reduction. A 2% discrepancy between different types of gages was identified, and it was recommended by Mr. Walton that this discrepancy be studied in more detail.
7. GOAL. To improve confidence in 120mm chamber pressure measurement, either by providing explanations for artifacts in differential pressure records or by developing an improved procedure for pressure measurement.
8. DESCRIPTION OF INVESTIGATION.
  - a. Drill and tap a 105mm tube for two 10mm-1 gages and two 1 1/8 inch-12 gages. (A 105mm tube has been chosen because the measurement difficulties experienced are not believed to be peculiar to the 120mm gun; the gage and mounting surfaces are the items of interest. The 105mm tubes are available and the ammunition is less expensive than 120mm.) Fire 5 rounds in each of 12 gage combinations.
  - b. Drill and tap a second 105mm tube for two 10mm-1 gages and two 1/2 inch-20 gages. Fire 5 rounds in each of 4 gage combinations.

120mm Differential Weapon Chamber Pressure Measurement - Con't

9. JUSTIFICATION.

a. Association with Mission. MTD will begin acceptance testing of a large amount of 120mm ammunition in August 1984. If chamber pressure measurements of this ammunition cannot be made with confidence, then this ammunition may be fielded in an unsafe condition.

b. Presently, all 120mm weapon chamber pressure measurements are made with a single model of pressure gage. This approach was taken to assure uniformity of measurements between different test organizations and the development of a usable data base. If this gage is not appropriate for the measurement, the data base will continue to grow, but it will be of little use. Additionally, the test community may be looking for a level of performance not realizable with the current state-of-the-art in pressure measurement. These situations should be quantified before 120mm ammunition is in an advanced state of production.

c. Dollar savings are not yet tangible. A lack of confidence in the pressure measurement during ammunition acceptance testing may cause a production delay when marginal results are encountered.

d. Numerous 120mm tests have been conducted. The large volume of testing scheduled for late FY 84 and FY 85 is of primary concern.

120mm Differential Weapon Chamber Pressure Measurement - Con't

10. RESOURCES.

a. Financial.

	Dollars (Thousands)	
	<u>FY 84</u>	<u>FY 85</u>
	<u>In-House</u>	<u>In-House</u>
Personnel Compensation	34	4
Materials and Supplies	4	0
General and Administrative	0	1
	<u>38</u>	<u>5</u>

b. Obligation Plan

	<u>FY 84</u>				Total
FQ	1	2	3	4	
	0	0	5	33	38
	<u>FY 85</u>				
FQ	1	2	3	4	Total
	5	0	0	0	5

c. In-House Personnel

	Man-Hours	
	<u>FY 84</u>	<u>Available</u>
<u>Number</u>	<u>Required</u>	
Electronic Engineer, GS-0855	1	320
Mechanical Engineer, GS-0830	1	300
	<u>620</u>	<u>620</u>

11. INVESTIGATION SCHEDULE.

	<u>FY 84</u>	<u>FY 85</u>
O N D J F M A M J J A S	O N D J F M A M J J A S	
In-House	- - - - -	- R

12. ASSOCIATION WITH TOP PROGRAM. This investigation will result in improved procedures for weapon chamber pressure measurement. TOP 3-2-810 will be revised accordingly.

13. AUTHENTICATION.

EDWARD V. SOMODY  
Chief  
Methodology and Test Management Division  
MATERIEL TESTING DIRECTORATE

## APPENDIX B - DATA ACQUISITION EQUIPMENT MATCHING PROCEDURE

The output of the programmable signal generator (PSG) should be connected to a T which is connected to two calibration capacitors which are connected to the two charge amplifier inputs. The setup parameters remain the same as for normal data acquisition except that the gage factors for each channel should be set to the appropriate calibration capacitor value (in microfarads). The PSG should be programmed for the following settings:

Frequency - 50 Hz

Amplitude - 9V/GAIN of channel

Offset - 0V

Burst mode - 1 cycle

Sine Wave

Inverted output

Once the appropriate settings have been made data should be acquired by loading, arming, triggering the PSG and transferring. Program QPEAK should be run to process the data. The scaled peak should be noted. Program CDIFF should be run to difference the data. Program QPEAK should be run on the difference data. The ratio of the difference peak to the input peak gives a measure of the peak error. Program QPLOT should be run to check the shape of the difference. If a large peak difference or a nonsymmetrical difference is found then the device circuit cards must be swapped one at a time and the procedure repeated until the problem or problems are isolated. Program CALX must be used in the swapping process to assign calibration factors.

If an offset/amplifier is employed in the system, then the bipolar signal will result in clipping of the negative portion of the signal. In this case, a transducer simulator producing a unipolar pulse will be useful. If a unipolar signal is not available, then the offset/amplifier should be placed in bypass mode and the above procedure applied. When satisfied with those results, the offset/amplifier should be activated again and the positive peak only checked for offset/amplifier performance.

APPENDIX C - GAGE CALIBRATION RECORDS

TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840810

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR  
KIST 6211 168650 MEF R. MILLER

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
13 8.187 312 0.1214

SI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
	12815	6.39	0.122	225	0.21
	12198	6.08	0.122	169	0.17
	10952	5.46	0.122	-31	-0.03
	9715	4.85	0.121	-151	-0.19
	8498	4.24	0.121	-116	-0.17
	7272	7.26	0.121	-110	-0.18
	6751	7.04	0.121	-142	-0.25
	4671	4.82	0.121	-141	-0.35
	3613	7.22	0.121	-61	-0.20
	2408	4.81	0.120	27	0.14
	1801	9.00	0.120	53	0.35
	1199	5.99	0.120	128	1.28
	591	5.94	0.119	150	2.99

TRANSDUCER CALIBRATION REPORT # 84 LP-<sup>#</sup> 1

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151650	MEF	WALTON

DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.136	-132	0.1232

CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
12931	6.45	0.123	68	0.06
12327	6.14	0.123	156	0.16
11092	5.53	0.123	108	0.12
9848	4.91	0.123	-10	-0.01
8609	4.30	0.123	-96	-0.14
7366	7.35	0.123	-201	-0.34
6141	6.13	0.123	-173	-0.35
4915	4.91	0.123	-144	-0.36
3694	7.37	0.123	-75	-0.25
2480	4.95	0.124	48	0.24
1867	9.33	0.124	60	0.40
1256	6.28	0.126	90	0.30
652	6.55	0.130	16?	3.38

TRANSDUCER CALIBRATION REPORT # 84 LP- *#2*

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

: DATE 840912

3F

E MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
ST 6211	168658	MEF	R. MILLER

POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
3	8.329	520	0.1189

CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
12581	6.26	0.120	309	0.29
11965	5.96	0.120	180	0.18
10724	5.34	0.119	-162	-0.18
9537	4.75	0.119	-50	-0.06
8328	4.14	0.119	-116	-0.17
7123	7.10	0.119	-150	-0.25
5921	5.90	0.118	-162	-0.32
4722	4.71	0.118	-148	-0.37
3523	6.99	0.117	-141	-0.47
2336	4.62	0.117	-22	-0.11
1745	8.65	0.116	56	0.38
1155	5.73	0.116	141	1.41
570	5.69	0.114	265	5.29

TRANSDUCER CALIBRATION REPORT # 84 LP- 7

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840810

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	168658	MEF	R. MILLER

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.447	105	0.1181

SI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
	12458	6.20	0.119	340	0.32
	11837	5.89	0.118	94	0.09
	10630	5.29	0.118	-100	-0.11
	9446	4.71	0.118	-101	-0.13
	8261	4.11	0.118	-111	-0.16
	7070	7.05	0.118	-170	-0.28
	5887	5.87	0.118	-170	-0.34
	4705	4.69	0.118	-153	-0.38
	3539	7.02	0.118	1	0.00
	2363	4.69	0.118	67	0.34
	1771	8.79	0.118	65	0.43
	1167	5.87	0.119	130	1.30
	592	5.91	0.118	107	2.13

TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

ESC DATE 840912

F-BF

PAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	168653	MEF	R. MILLER

TA POINTS	K-(PSI/Pcb)	Y-(PSI)	SENS=(Pcb/PSI)
13	8.344	-22	0.1199

CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
12576	6.27	0.120	-91	-0.09
11968	5.96	0.120	-158	-0.16
10780	5.37	0.120	-75	-0.08
9604	4.79	0.120	117	0.15
8415	4.19	0.120	191	0.27
7200	7.18	0.120	57	0.09
6001	5.99	0.120	50	0.10
4807	4.79	0.120	87	0.22
3606	7.19	0.120	66	0.22
2398	4.78	0.120	-14	-0.07
1798	8.95	0.120	-23	-0.15
1190	5.93	0.119	-92	-0.92
588	5.89	0.118	-116	-2.31

TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840810

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	168653	MEF	R. MILLER

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.372	-199	0.1198

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12541	6.25	0.119	-207	-0.20
100	11944	5.95	0.119	-211	-0.21
90	10765	5.37	0.120	-77	-0.09
80	9596	4.79	0.120	132	0.16
70	8399	4.19	0.120	117	0.17
60	7216	7.20	0.120	212	0.35
50	6018	6.01	0.120	185	0.37
40	4822	4.81	0.121	167	0.42
30	3628	7.24	0.121	177	0.59
20	2421	4.84	0.121	69	0.35
15	1806	9.02	0.120	-84	-0.56
10	1193	5.96	0.119	-209	-2.09
5	589	5.91	0.118	-271	-5.42

TRANSDUCER CALIBRATION REPORT # 84 LP- #3

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841018

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151652	MEF-HWN	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.060	328	0.1233

CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
13044	6.50	0.124	457	0.44
12410	6.18	0.124	345	0.35
11119	5.54	0.124	-53	-0.06
9882	4.92	0.124	-25	-0.03
8618	4.29	0.123	-216	-0.31
7342	7.32	0.122	-495	-0.82
6119	6.10	0.122	-355	-0.71
4875	4.86	0.122	-383	-0.96
3652	7.24	0.122	-239	-0.80
2443	4.84	0.122	16	0.08
1836	9.12	0.122	128	0.86
1239	6.16	0.124	317	0.17
642	6.43	0.128	501	0.03

TRANSDUCER CALIBRATION REPORT # 84 LP- ~~2~~

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840917

AF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151652	MEF	MALTON

*DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.036	408	0.1235

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	13052	6.50	0.124	296	0.28
100	12429	6.19	0.124	289	0.29
90	11173	5.56	0.124	194	0.22
80	9899	4.92	0.124	-38	-0.05
70	8616	4.29	0.123	-350	-0.50
60	7373	7.34	0.123	-341	-0.57
50	6130	6.11	0.123	-333	-0.67
40	4893	4.87	0.122	-273	-0.68
30	3643	7.22	0.121	-314	-1.05
20	2437	4.82	0.122	-12	-0.06
15	1826	9.04	0.122	82	0.55
10	1231	6.10	0.123	299	2.99
5	634	6.33	0.127	501	10.01

TRANSDUCER CALIBRATION REPORT # 84 LP- 7

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151652	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.028	377	0.1237

PSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
0	13087	6.57	0.125	441	0.42
0	12443	6.19	0.124	278	0.28
0	11170	5.56	0.124	56	0.06
0	9907	4.93	0.124	-89	-0.11
0	8640	4.29	0.123	-261	-0.37
0	7378	7.34	0.123	-386	-0.64
0	6134	6.11	0.123	-379	-0.76
0	4891	4.87	0.122	-356	-0.89
0	3567	7.26	0.122	-187	-0.62
0	2447	4.85	0.122	22	0.11
5	1833	9.09	0.122	92	0.62
0	1233	6.09	0.123	276	2.76
5	637	6.36	0.127	492	9.84

TRANSDUCER CALIBRATION REPORT # 84 LP- ~~7~~ 3

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841018

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151647	MEF-HWW	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.346	-101	0.1201

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12617	6.29	0.120	194	0.19
100	12030	6.00	0.120	299	0.30
90	10817	5.40	0.120	175	0.19
80	9602	4.79	0.120	34	0.04
70	8379	4.18	0.120	-174	-0.25
60	7160	7.15	0.119	-348	-0.58
50	5946	5.93	0.119	-479	-0.96
40	4766	4.76	0.119	-323	-0.81
30	3578	7.14	0.119	-239	-0.80
20	2412	4.81	0.121	28	0.14
15	1823	9.09	0.122	109	0.73
10	1247	6.22	0.125	306	3.06
5	661	6.63	0.132	419	8.37

TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840917

AF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151647	MEF	HALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.357	-220	0.1202

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
100	12599	6.28	0.120	74	0.07
100	12019	5.99	0.120	222	0.22
90	10830	5.39	0.120	289	0.32
80	9599	4.78	0.120	-0	-0.00
70	8378	4.17	0.120	-203	-0.29
60	7167	7.14	0.119	-323	-0.54
50	5971	5.95	0.119	-318	-0.64
40	4784	4.77	0.120	-239	-0.60
30	3602	7.17	0.120	-118	-0.39
20	2426	4.83	0.121	54	0.27
15	1835	9.13	0.122	114	0.76
10	1248	6.21	0.125	206	2.06
5	654	6.53	0.131	242	4.84

TRANSDUCER CALIBRATION REPORT # 84 LP-<sup>2</sup>/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151647	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.308	-161	0.1207

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12693	6.31	0.121	288	0.27
100	12088	6.01	0.121	268	0.27
90	10860	5.40	0.121	60	0.07
80	9646	4.80	0.121	-23	-0.03
70	8427	4.19	0.120	-154	-0.22
60	7205	7.17	0.120	-304	-0.51
50	5990	5.97	0.120	-398	-0.80
40	4790	4.77	0.120	-370	-0.92
30	3608	7.15	0.120	-186	-0.62
20	2434	4.82	0.122	63	0.31
15	1842	9.14	0.123	145	0.97
10	1257	6.21	0.126	286	2.86
5	660	6.59	0.132	325	6.50

TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840913

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR  
KIST 6211 168659 MRF R. MILLER

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
13 8.367 620 0.1181

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12490	6.22	0.119	128	0.12
100	11914	5.93	0.119	306	0.31
90	10686	5.32	0.119	28	0.03
80	9485	4.72	0.119	-17	-0.02
70	8269	4.12	0.118	-195	-0.28
60	7083	7.06	0.118	-116	-0.19
50	5877	5.85	0.118	-206	-0.41
40	4669	4.65	0.117	-315	-0.79
30	3487	6.90	0.115	-202	-0.67
20	2313	4.58	0.116	-23	-0.12
15	1721	8.53	0.115	23	0.15
10	1145	5.68	0.115	202	2.02
5	570	5.70	0.114	388	7.76

TRANSDUCER CALIBRATION REPORT # 84 LP- 21

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840810

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	168659	MEF	R. MILLER

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.405	315	0.1183

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12491	6.22	0.119	296	0.28
100	11887	5.92	0.119	221	0.22
90	10666	5.31	0.119	-41	-0.05
80	9451	4.71	0.118	-249	-0.31
70	8268	4.12	0.118	-197	-0.28
60	7078	7.06	0.118	-193	-0.32
50	5901	5.89	0.118	-87	-0.17
40	4714	4.70	0.118	-63	-0.16
30	3530	7.00	0.118	-13	-0.04
20	2345	4.65	0.117	22	0.11
15	1749	8.68	0.117	13	0.09
10	1168	5.78	0.117	133	1.33
5	576	5.75	0.115	158	3.16

## TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840912

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	168650	MEF	R.MILLER

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.109	383	0.1224

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12889	6.41	0.123	-104	-0.10
100	12285	6.11	0.123	1	0.00
90	11059	5.51	0.123	57	0.06
80	9837	4.89	0.123	154	0.19
70	8590	4.28	0.123	35	0.05
60	7356	7.33	0.123	31	0.05
50	6114	6.10	0.122	-38	-0.08
40	4874	4.86	0.122	-96	-0.24
30	3632	7.21	0.121	-162	-0.54
20	2413	4.78	0.121	-50	-0.25
15	1796	8.90	0.120	-50	-0.35
10	1191	5.30	0.119	38	0.38
5	591	5.92	0.118	184	5.66

TRANSDUCER CALIBRATION REPORT # 84 LP-~~#~~<sup>2</sup>

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840915

AF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151650	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.128	-218	0.1236

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
105	12970	6.47	0.124	197	0.19
100	12338	6.15	0.123	64	0.06
90	11113	5.54	0.123	106	0.12
80	9872	4.92	0.123	18	0.02
70	8640	4.31	0.123	8	0.01
50	7289	7.37	0.123	-160	-0.27
50	6153	6.14	0.123	-204	-0.41
40	4914	4.90	0.123	-280	-0.70
30	3682	7.34	0.123	-292	-0.57
20	2464	4.91	0.123	-188	-0.34
15	1863	9.28	0.124	-76	-0.51
10	1209	5.43	0.129	259	2.53
5	710	7.10	0.141	549	10.98

## TRANSDUCER CALIBRATION REPORT # 84 LP-

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151653	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.238	-292	0.1221

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
105	12784	6.38	0.122	26	0.03
100	12181	6.07	0.122	58	0.06
90	10971	5.47	0.122	91	0.10
90	9755	4.87	0.122	70	0.05
70	8523	4.25	0.122	-77	-0.17
50	7318	3.80	0.122	-3	-0.06
50	6092	6.08	0.122	-107	-0.21
40	4868	4.86	0.122	-186	-0.46
30	3649	7.28	0.122	-229	-0.76
20	2450	4.91	0.122	-25	-0.12
15	1861	5.31	0.124	51	0.28
10	1267	5.53	0.127	143	0.43
5	665	6.68	0.132	185	0.71

## TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840915

AF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

KIST 6211 151653 MEF WALTON

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)

13 8.287 -499 0.1218

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12722	6.33	0.121	-75	-0.07
100	12125	6.04	0.121	-23	-0.02
90	10948	5.45	0.122	229	0.25
80	9730	4.84	0.122	129	0.16
70	8503	4.23	0.121	-37	-0.05
60	7290	7.27	0.122	-86	-0.14
50	6082	6.06	0.122	-101	-0.20
40	4866	4.85	0.122	-177	-0.44
30	3664	7.27	0.122	-134	-0.45
20	2477	4.51	0.124	27	0.13
15	1877	9.30	0.125	57	0.38
10	1291	6.35	0.123	113	1.13
5	671	6.73	0.125	77	1.56

TRANSDUCER CALIBRATION REPORT # 84 LP- ~~#~~2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841018

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
KIST 6211	151653	MEF-HWW	WALTON

*DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	8.255	-435	0.1221

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	12768	6.36	0.122	-28	-0.03
100	12195	6.07	0.122	239	0.24
90	10961	5.45	0.122	49	0.05
80	9750	4.86	0.122	51	0.06
70	8532	4.25	0.122	1	0.00
50	7309	2.29	0.122	-98	-0.16
50	6077	6.05	0.122	-271	-0.54
40	4867	4.86	0.122	-259	-0.65
30	3667	7.27	0.122	-160	-0.53
20	2482	4.92	0.124	51	0.26
15	1877	9.32	0.125	59	0.49
10	1207	6.40	0.129	192	1.92
5	679	6.80	0.135	172	3.44

## TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841025

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG ES15M YPES25 MEF-HWW WALTON

*DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
5	1.614	-390	0.6239

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
80	49827	4.98	0.623	39	0.05
70	43561	4.35	0.622	-75	-0.11
60	37426	3.74	0.624	21	0.03
50	31232	3.12	0.625	24	0.05
40	25019	4.98	0.625	-6	-0.02
30	18826	3.75	0.628	-2	-0.01

## TRANSDUCER CALIBRATION REPORT # 84 LP- \*

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840808

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
ES15M	YPES8	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	1.565	-41	0.6394

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	67003	3.35	0.638	-166	-0.16
100	63869	3.19	0.639	-73	-0.07
90	57474	5.74	0.639	-82	-0.09
80	51151	5.11	0.639	21	0.03
70	44824	4.48	0.640	118	0.17
60	38449	3.84	0.641	140	0.23
50	32062	3.20	0.641	143	0.29
40	25677	5.11	0.642	150	0.37
30	19278	3.83	0.643	133	0.44
20	12811	2.55	0.641	11	0.05
15	9547	4.76	0.636	-96	-0.66
10	6312	3.14	0.631	-161	-1.61
5	3134	3.13	0.627	-135	-2.71

TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

ES15M YPES8 MEF WALTON

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
4 1.554 134 0.6365

SI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
	12794	2.54	0.640	20	0.10
	9552	4.75	0.637	-19	-0.13
	6333	3.15	0.633	-22	-0.22
	3144	3.13	0.629	21	0.42

TRANSDUCER CALIBRATION REPORT # 84 LP- #3

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840809

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
ES15M	YPES8	MEF	WALTON

*DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
4	1.552	126	0.6379

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
20	12814	2.54	0.641	11	0.06
15	9580	4.77	0.639	-7	-0.05
10	6350	3.16	0.635	-21	-0.21
5	3151	3.14	0.630	16	0.32

TRANSDUCER CALIBRATION REPORT # 84 LP- 74

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840814

BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

ES15M YPES8 MEF WALTON

DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)

5 1.568 43 0.6371

CHARGE OUTPUT VOLTS SENS DEVIATION %ERROR

50862	5.07	0.636	-223	-0.28
44789	4.47	0.640	257	0.37
9544	4.75	0.636	4	0.03
6336	3.16	0.634	-24	-0.24
3153	3.14	0.631	-14	-0.28

## TRANSDUCER CALIBRATION REPORT # 84 LP- #5

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840814

BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

ES15M YPES8 MEF WALTON

*DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
5	1.562	81	0.6389

PSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
30	51069	5.10	0.638	-163	-0.20
0	44891	4.48	0.641	189	0.27
15	9552	4.75	0.637	-2	-0.01
0	6335	3.15	0.634	-25	-0.25
5	3150	3.14	0.630	0	0.01

## TRANSDUCER CALIBRATION REPORT # 84 LP- #6

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

SC DATE 841024

-BF

E MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

PG ES15M YPES8 MEF WALTON

A POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)

6 1.552 -139 0.6459

CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
51610	5.15	0.645	-39	-0.05
45192	4.51	0.646	1	0.00
38788	3.87	0.646	62	0.10
32288	3.22	0.646	-27	-0.05
25899	5.15	0.647	57	0.14
19384	3.86	0.646	-54	-0.18

TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841025

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG ES15M YPES27 MEF-HWM WALTON

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/ SI)  
6 1.582 -264 0.6351

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
80	50778	5.07	0.635	66	0.08
70	44333	4.43	0.633	-129	-0.18
60	38116	3.81	0.635	35	0.06
50	31802	3.18	0.636	46	0.09
40	25443	5.06	0.636	-13	-0.03
30	19127	3.81	0.638	-5	-0.02

## TRANSDUCER CALIBRATION REPORT # 84 LP- #2

ABERDEEN PROVING GROUNDS, MARYLAND

## PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

; DATE 841025

;F

; MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

; ES15M YPES27 MEF-HWW WALTON

POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
; 1.583 -227 0.6345CHARGE OUTPUT VOLTS SENS DEVIATION %ERROR  
50671 5.06 0.633 -32 -0.04  
44363 4.43 0.634 -16 -0.02  
38103 3.80 0.635 77 0.13  
31735 3.17 0.635 -1 -0.00  
25414 5.06 0.635 -6 -0.01  
19085 3.30 0.636 -22 -0.07

TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841025

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG E15M YPEM7 MEF-HWW WALTON

DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
6 1.649 -670 0.6137

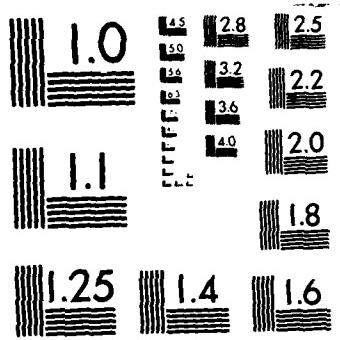
CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
48915	4.89	0.611	-1	-0.00
42811	4.28	0.612	-67	-0.10
36821	3.67	0.614	55	0.09
30765	3.07	0.615	68	0.14
24642	4.91	0.616	-31	-0.08
18583	3.70	0.619	-24	-0.08

AD-A156 775    METHODOLOGY INVESTIGATION OF 120-MM DIFFERENTIAL WEAPON    4/4  
CHAMBER PRESSURE MEASUREMENT(U) ARMY COMBAT SYSTEMS  
TEST ACTIVITY (PROV) ABERDEEN PROVING GRO.

UNCLASSIFIED    V A BETZOLD ET AL. FEB 85 USACSTA-6163    F/G 14/2    NL



CNO  
INFO  
DPW



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS 1963-A

## TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841025

AF-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG E15M YPEM8 MEF-HWW WALTON

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)  
6 1.563 -992 0.6513

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
80	51712	5.16	0.646	-164	-0.20
70	45473	4.54	0.650	85	0.12
60	39124	3.90	0.652	161	0.27
50	32629	3.26	0.653	8	0.02
40	26209	5.22	0.655	-26	-0.06
30	19787	3.94	0.660	-64	-0.21

TRANSDUCER CALIBRATION REPORT # 84 LP- #/

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840808

BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG 78 YMS50 MEF HALTON

\*DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)

3 0.527 268 1.8898

KPSI CHARGE OUTPUT VOLTS SENS DEVIATION %ERROR

50	170183	3.39	1.891	19	0.02
50	151112	3.02	1.889	-39	-0.05
70	132260	6.60	1.889	19	0.03

## TRANSDUCER CALIBRATION REPORT # 84 LP-#2

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840813

BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATED FOR

YPG T8 YMS50 MEF WALTON

#DATA POINTS K=(PSI/Pcb) Y=(PSI) SENS=(Pcb/PSI)

13 0.529 116 1.8880

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	%ERROR
105	198287	3.96	1.888	-95	-0.09
100	198683	3.77	1.887	-171	-0.17
90	170197	3.40	1.891	60	0.07
80	151272	3.02	1.891	59	0.07
70	132424	6.61	1.892	98	0.14
60	113543	5.67	1.892	123	0.21
50	94461	4.72	1.890	46	0.06
40	75613	7.55	1.890	75	0.19
30	56542	5.65	1.885	-3	-0.01
20	37517	7.47	1.876	-57	-0.29
15	28060	5.58	1.871	-55	-0.37
10	18588	3.70	1.859	-61	-0.61
5	9203	4.59	1.841	-20	-0.40

TRANSDUCER CALIBRATION REPORT # 84 LP- 23

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841026

AF-BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
YPG EXT T8	YMS50	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
6	0.527	-111	1.9012

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
80	151913	3.03	1.899	-47	-0.06
70	133136	6.65	1.902	57	0.08
60	114083	5.70	1.901	15	0.02
50	95029	4.75	1.900	-32	-0.06
40	76159	7.61	1.904	28	0.07
30	57095	5.71	1.903	-20	-0.07

TRANSDUCER CALIBRATION REPORT # 84 LP- # /

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840808

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
YPG T8	YMS51	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
3	0.527	902	1.8769

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
90	169121	3.37	1.879	-10	-0.01
80	150193	2.99	1.877	20	0.02
70	131153	6.55	1.874	-10	-0.01

TRANSDUCER CALIBRATION REPORT # 84 LP- <sup>#2</sup>

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 840813

BF

GAGE MODEL	SERIAL NO.	CALIBRATED BY	CALIBRATED FOR
YPG T8	YMS51	MEF	WALTON

#DATA POINTS	K=(PSI/Pcb)	Y=(PSI)	SENS=(Pcb/PSI)
13	0.527	819	1.8682

KPSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
105	197790	3.95	1.884	21	0.02
100	188243	3.76	1.882	-9	-0.01
90	169402	3.38	1.882	65	0.07
80	150087	3.00	1.876	-111	-0.14
70	131405	6.56	1.877	47	0.07
60	112384	5.61	1.873	26	0.04
50	93405	4.66	1.868	28	0.06
40	74369	7.42	1.859	-1	-0.00
30	55225	5.51	1.841	-88	-0.29
20	36235	7.20	1.812	-91	-0.46
15	26780	5.32	1.785	-72	-0.49
10	17457	3.47	1.746	16	0.16
5	8257	4.11	1.651	169	0.36

## TRANSDUCER CALIBRATION REPORT # 84 LP- #3

ABERDEEN PROVING GROUNDS, MARYLAND

PHYSICAL TEST BRANCH...PRESSURE GAGE SECTION

DISC DATE 841026

OT-BF

GAGE MODEL SERIAL NO. CALIBRATED BY CALIBRATOR

YPG EXT T8 YMS51 MCF WALTON

#DATA POINT	= (PSI/Pcb)	Y= (PSI)	SENS=(Pcb/PSI)
2	0.525	707	1.8787

PSI	CHARGE	OUTPUT VOLTS	SENS	DEVIATION	XERROR
80	10724	3.01	1.884	-98	-0.12
70	102081	6.60	1.887	-96	0.15
60	102322	5.64	1.882	-97	0.07
50	93759	4.69	1.875	-92	-0.06
40	74792	3.46	1.870	-5	0.01
30	55794	2.11	1.857	-23	-0.03

#### APPENDIX D - REFERENCES

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2. Francis, C. Lee, RDI Task, Final Report of Research and Development of Software, Ballistic Test Site Terminal, TECOM Project No. 5-CO-AP0-DFW-203. US Army Aberdeen Proving Ground, Report APG-MT-5952, January 1984. (Distribution unlimited.)
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